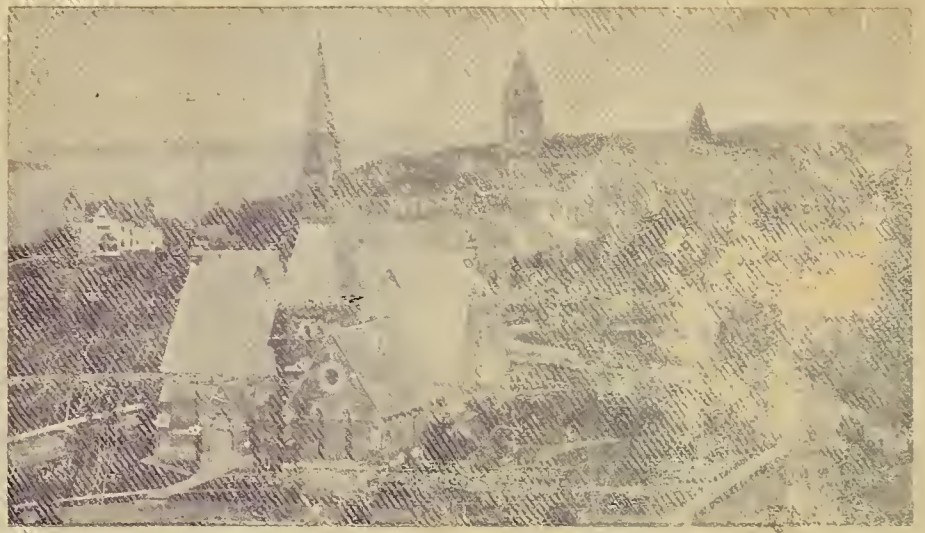
Cornell University



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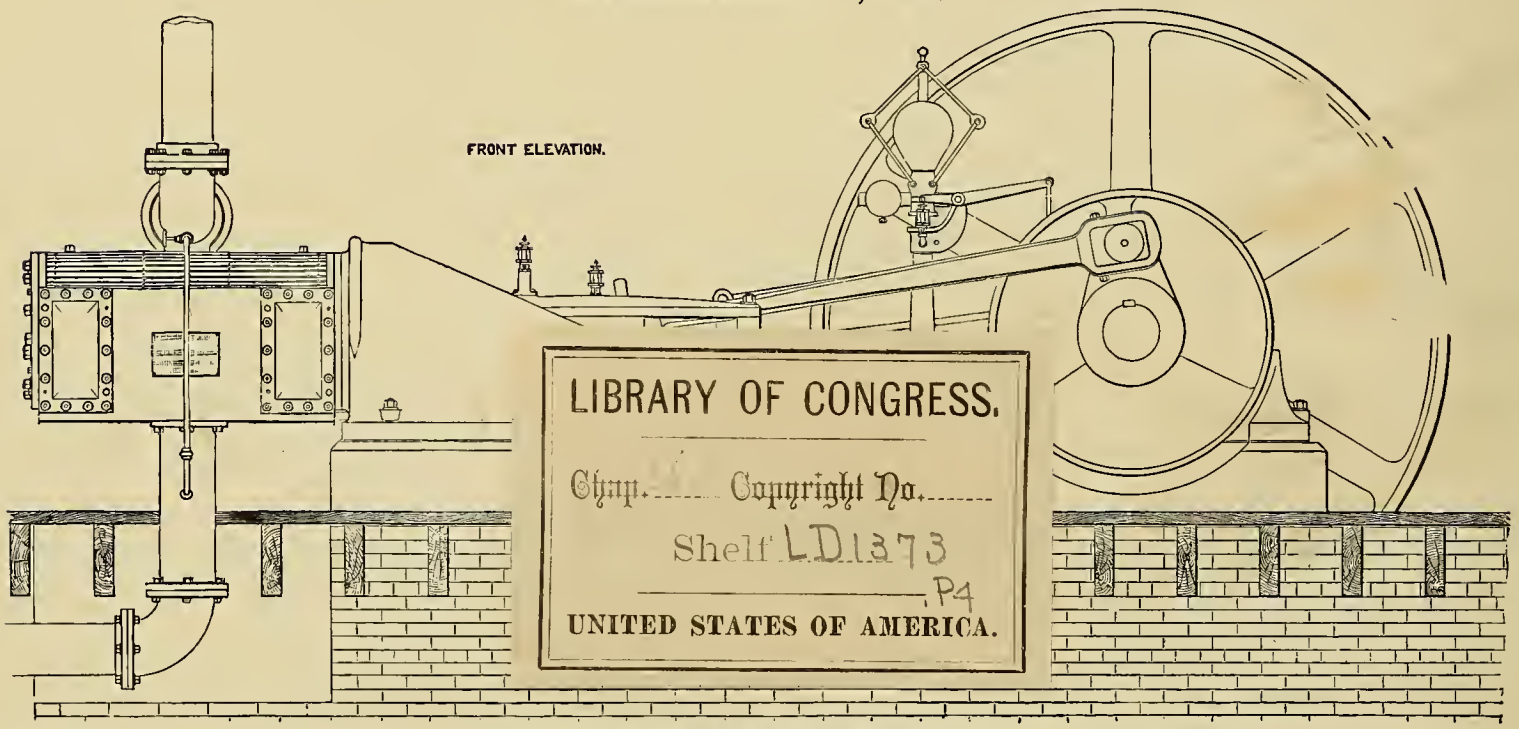

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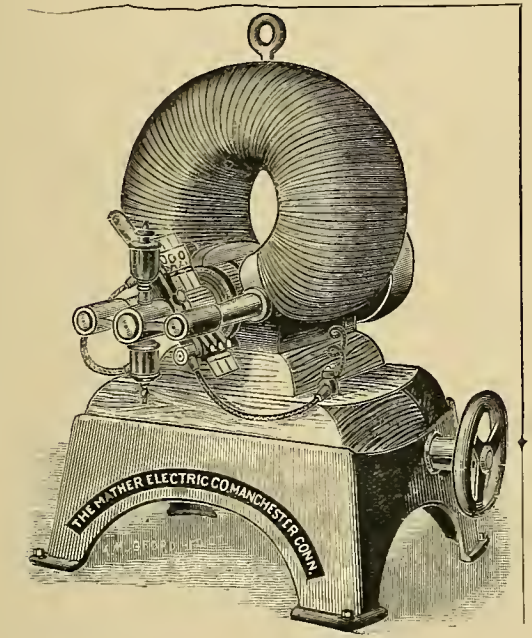

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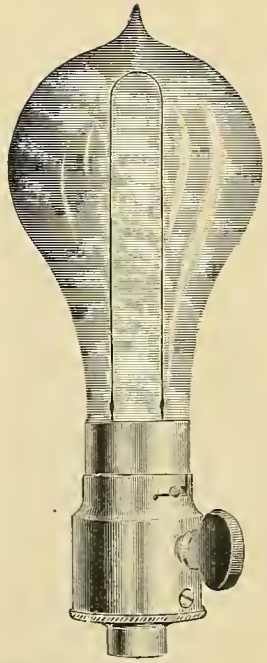

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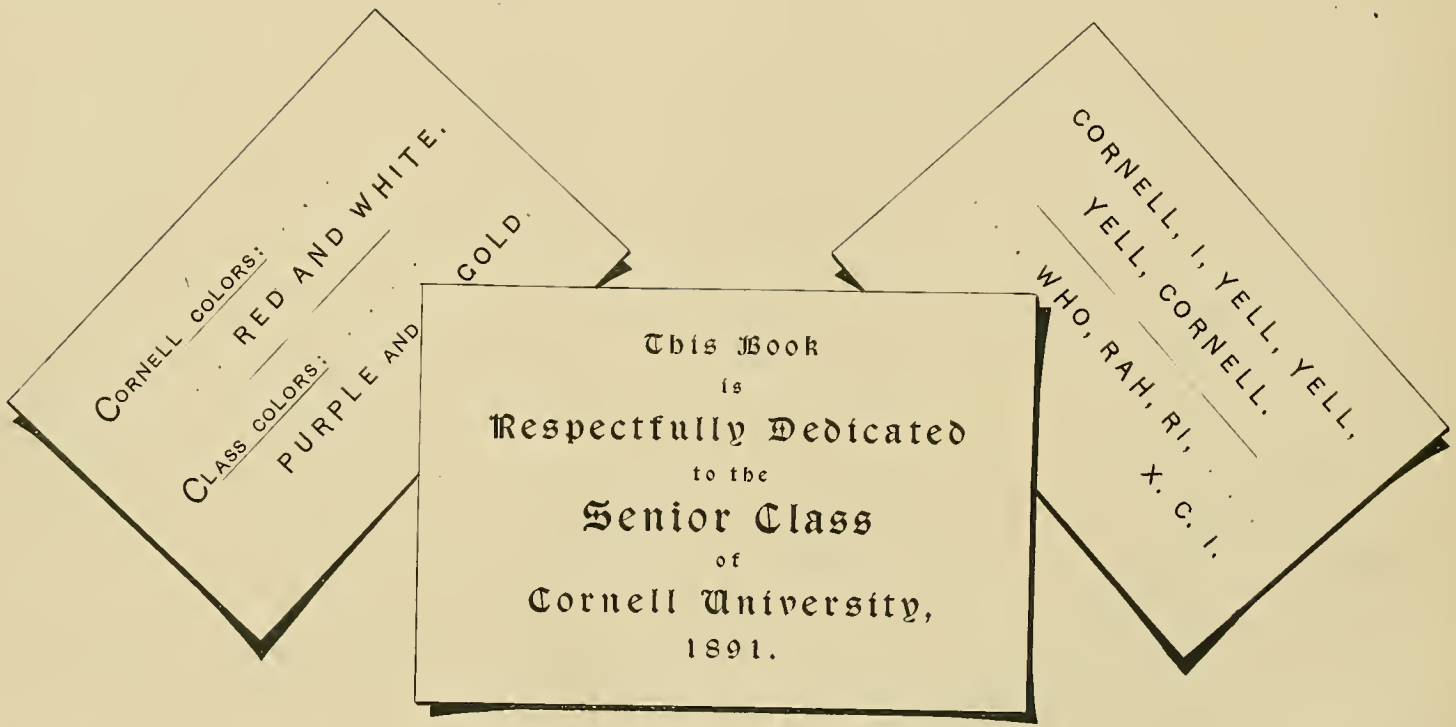
Cornell colors: Red and White.
Class colors: Purple and Gold.
This Book
is
Respectfully Dedicated
to the
Senior Class
of
Cornell University,
1891.
Cornell, I, Yell, Yell, Yell,
Yell, Cornell.
Who, Rah, Ri,
X. C. I.

CORNELL UNIVERSITY:

HER

GENERAL AND TECHNICAL COURSES

BY

FRANK C. PERKINS,

(ASSOCIATE MEMBER OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.)

"I would found an institution where any person can find instruction in any study."—EZRA CORNELL.

ART-PRINTING WORKS OF MATTHEWS, NORTHRUP & CO., BUFFALO, N. Y.
· 1891 ·

Single Copies of this book will be mailed, prepaid to any address, on receipt of price. Address as above.

Preface.

IN THE preparation of this work, the object has been to give the readers a pictorial and descriptive view of the opportunities offered by Cornell University for General and Technical education.

The General Courses include those leading to degrees in Arts, Philosophy, Letters, and Science. The facilities offered in the several branches included in these courses are believed to be unsurpassed in this country; and they will be found duly set forth in the illustrations and in the descriptive text.

The Technical Courses include Agriculture, Architecture, Chemistry, Civil Engineering, Electrical Engineering, Mechanical Engineering, and Law. In all of these departments the material equipment is excellent; in the most of them it is believed to be unequalled. The illustrations and descriptions are designed to show the opportunities that are so abundantly offered in so many branches of human knowledge. In 1890-91 the corps of instruction contains the names of one hundred and seven professors and instructors, besides twenty-five special lecturers. The number of students enrolled during the same year is 1,382, of whom more than a hundred are pursuing graduate courses.

FRANK C. PERKINS.

CORNELL UNIVERSITY, Ithaca, N. Y., *April, 1891.*

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CONTENTS.

1. The Founders.

FROM the Federal Land Grant of 1862, which was introduced into Congress by the Honorable Justin S. Morrill of Vermont, the portion received by New York was 990,000 acres. Every State was required to devote the fund received from the sale of the land-scrip to at least one institution of learning, in which, without excluding other branches, the main object should be the teaching of those studies which relate to Agriculture and the Mechanic Arts.

In 1865 Ezra Cornell, then a member of the New York Senate, offered to give $500,000 for the University on condition that the institution should be located in Ithaca. This condition was complied with, and the University was opened for instruction in October, 1868. Subsequently, Mr. Cornell bought of the State a large part of the scrip, binding himself to devote to the University all the profits derived from the sale of the lands. Mr. Cornell's endowment and the profits resulting from his wise policy have already amounted to more than $5,000,000.

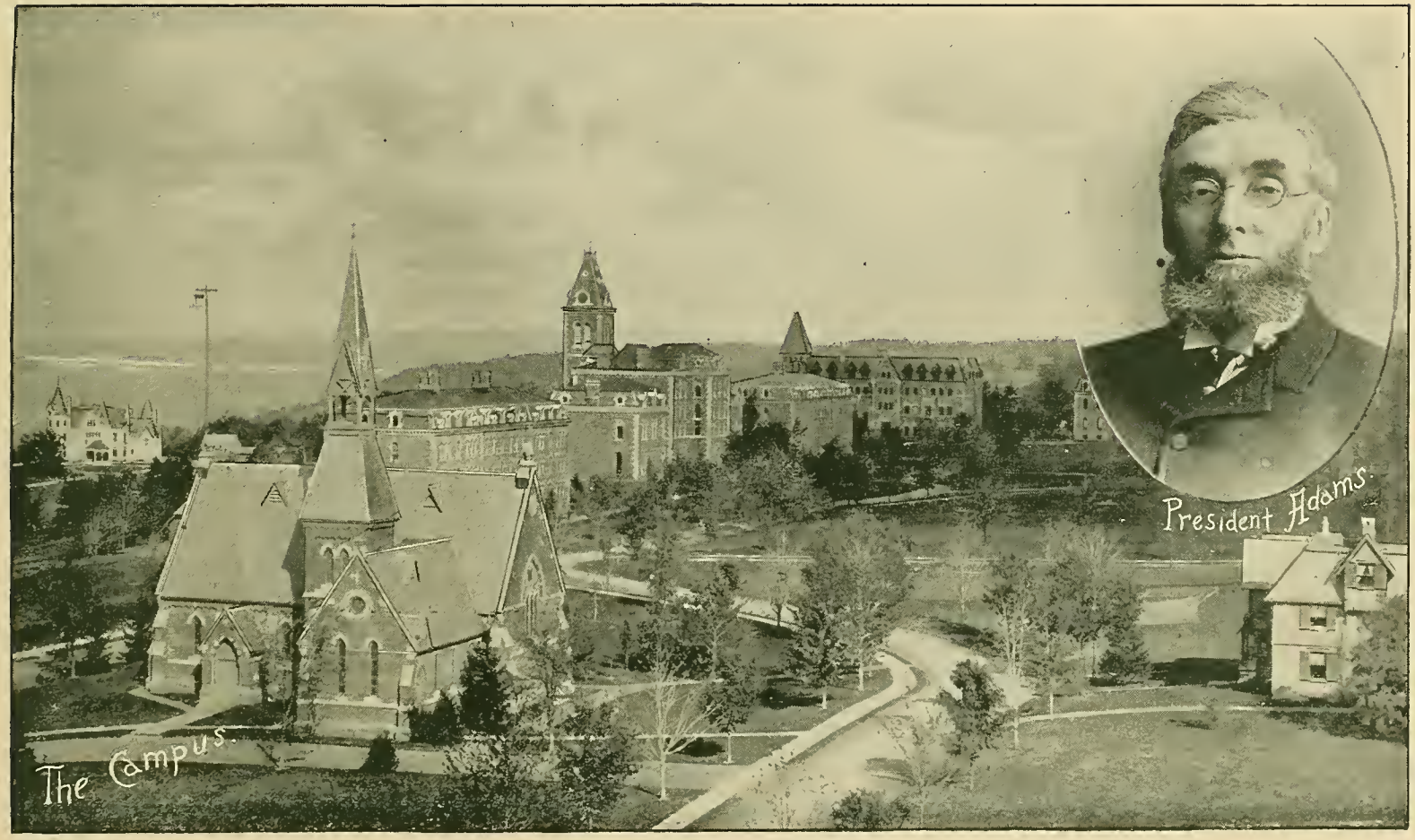
Associated with Mr. Cornell in the New York Senate was the Honorable Andrew D. White, who for several years had been a professor of history in the University of Michigan. He not only became Mr. Cornell's adviser, but he shaped the early history of the University, and was its President from its beginning until his resignation in 1885.

Soon after the establishment of the University Mr. Hiram Sibley of Rochester founded and partially equipped the Sibley College of Mechanical Engineering and the Mechanic Arts, by gifts amounting to date to nearly $200,000.

2. The Site of the University.

CORNELL UNIVERSITY is situated on the eastern slope of the Cayuga Lake valley, some five hundred feet above the head of the lake. This body of water stretches away in full view more than twenty miles to the north; and the valley leading to it extends some twelve or fifteen miles in the opposite direction, the whole forming a landscape of unsurpassed beauty. In the gorges between which the university is situated the waters of Cascadilla and Fall creeks descend more than five hundred feet in a succession of most picturesque cataracts and cascades.

The University domain, consisting of about two hundred and seventy acres, lies upon the somewhat undulating plateau between Fall Creek Gorge and Cascadilla Ravine. While the eastern portion of about one hundred and fifty acres is devoted to the uses of the College of Agriculture, a plateau near the western side constitutes what is known as the campus. The grounds have been laid out with great care, are decorated with ornamental trees and shrubs, and are made to illustrate the courses of instruction in botany, horticulture, and arboriculture. Upon the grounds there are eight stone buildings, five brick buildings, and thirty-one residences of professors and other officers. The view in the opposite cut is that taken from Sage College looking toward the northwest. At the opposite or south end of the campus is the Gymnasium. President Charles Kendall Adams has been at the head of the University since 1885.


President Adams.
The Campus.

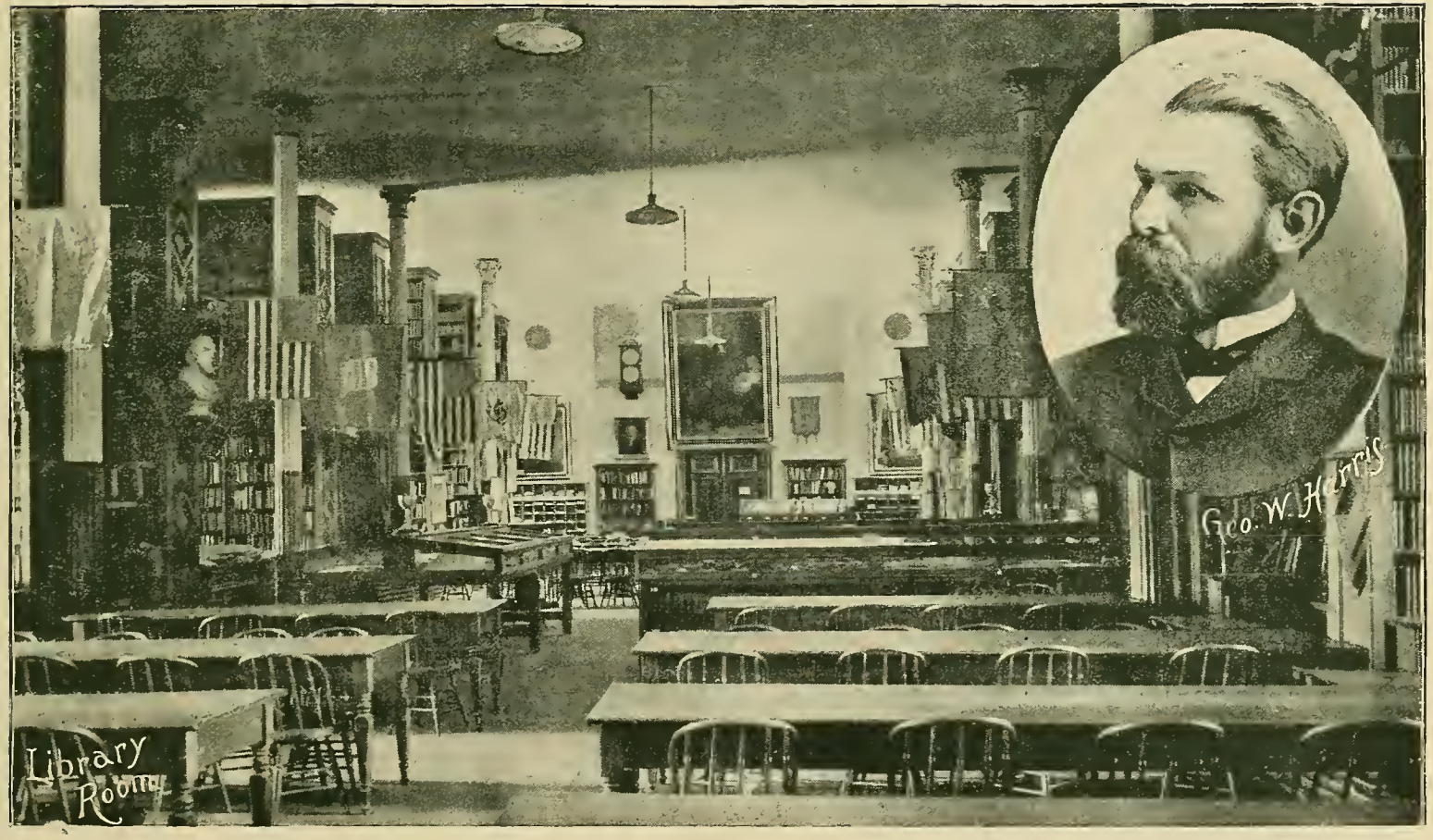
3. The Library Building.

THROUGH the munificence of the Honorable Henry W. Sage the University was enabled, in 1889, to begin the erection of the library building, a view of which is offered on the opposite page. The building was planned with great care for the purpose of providing in the most convenient form all the desirable appointments of a modern university library. Convenient storage is furnished for four hundred and eighty thousand volumes; and the reading room will accommodate three hundred and fifty readers. There are two rooms for the storage of books, a consulting library on the walls of the reading room, a special room for the accommodation of the President White library of forty thousand volumes in History and Political Science, and eight seminary rooms, where special classes will find the books most needed for the advanced work of original investigation. The exterior of the building is constructed of Ohio and Lake Superior sandstone, and the structure is strictly fire-proof in all its parts. The tower is to carry the clock and the University chime. It is expected that the building will be ready for occupation in the summer of 1891. Besides erecting the building at an expense of nearly three hundred thousand dollars, Mr. Sage gives an endowment of three hundred thousand dollars, as a perpetual fund, the income of which is forever to be devoted to the purchasing of books.

The New Library Building.

4. The Library Room.

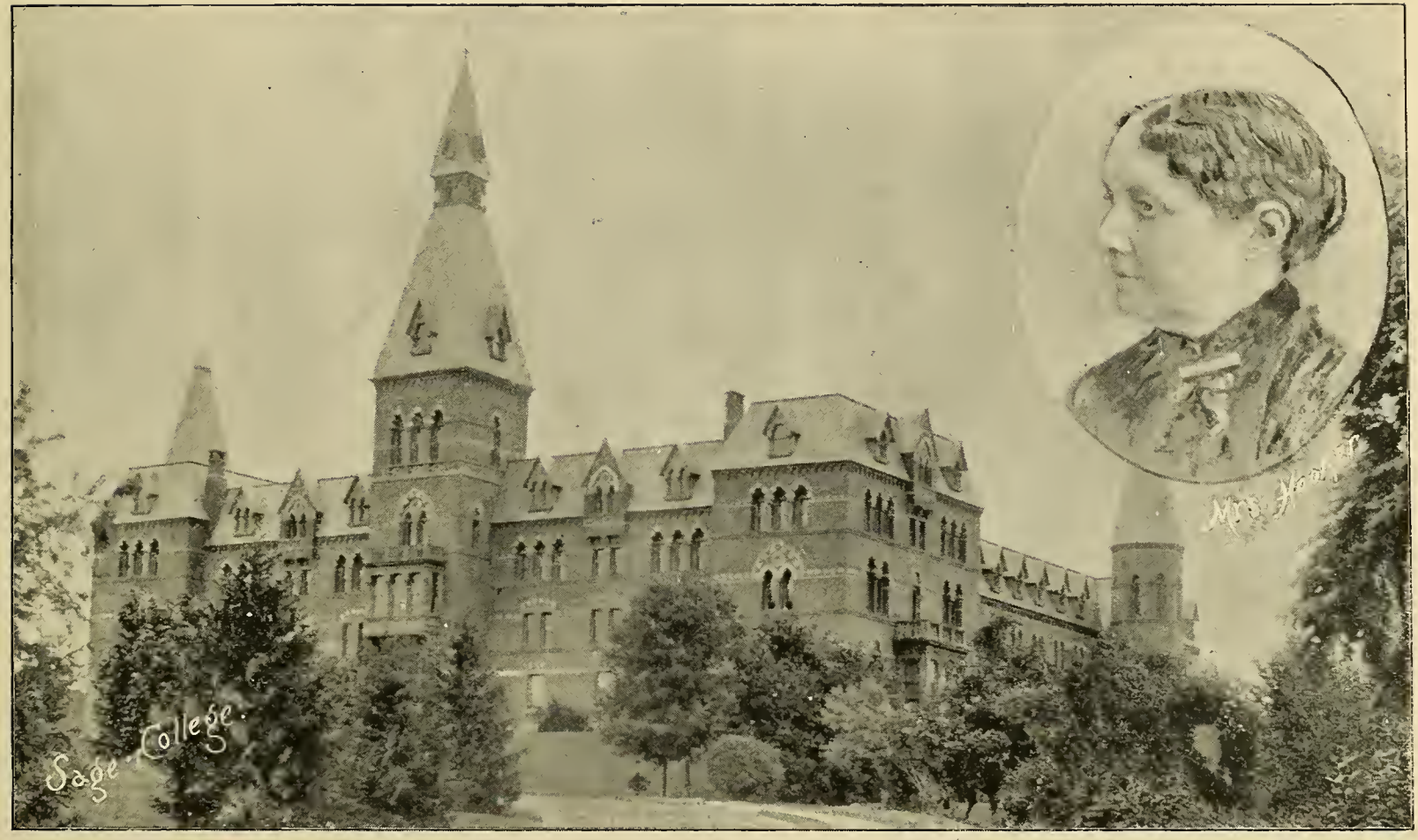
UNTIL the new library building is completed the general library will continue to occupy, as it has for nearly twenty years, the large room on the ground floor of McGraw Hall. Here and in the adjacent rooms is accommodated the general library of the University, now consisting of nearly one hundred and ten thousand volumes. The library has been selected with special care. The Anthon Library of nearly seventeen thousand volumes, the Bopp Library of nearly three thousand volumes, the Goldwin Smith Library of thirty-five hundred volumes, the Sparks Library of more than five thousand volumes, have all been supplemented from time to time in such a way as to contribute most to the needs of professors and students. The President White Library of History and Political Science, consisting of nearly forty thousand volumes, is peculiarly rich in books on the History of Superstition, on the Reformation, on the French Revolution, and on the Civil War. The library has on file for the use of readers and students of the University the current numbers of more than five hundred literary and scientific periodicals. The staff required to administer the library and make it most accessible to professors and students consists of eleven persons. The librarian is Mr. George W. Harris.


Library
Room
Geo. W. Harris

5. Sage College.

THE SAGE COLLEGE for women was erected between 1874 and 1876 by Mr. Henry W. Sage. The building with its endowment was presented by this princely benefactor on condition that education should forever be provided for women as broadly as for men. The building, of which a view is given on the opposite page, presents a façade one hundred and sixty-eight feet in length, a depth of forty-one feet, and a height of four stories. The north wing extends toward the east eighty-five feet, and the south wing one hundred and twelve feet in the same direction. The building is a home for students, and does not constitute a separate department or school The young women attending Cornell University receive the same instruction as young men. In a separate gymnasium, however, the young women are required to take exercise under the direction of a professor of physical culture. Besides the private rooms, dining hall, and parlors, the building contains a large lecture room, museums, laboratories, green-houses, forcing-houses, and other necessary facilities for the pursuit of botany, floriculture, and ornamental gardening.

The business manager, Mr. E. P. Gilbert, has charge of all the material interests of the college, including the care of the students' rooms and the dining table ; while the moral and social interests of the young women are entrusted to the principal, Mrs. Ellen K. Hooker.


Sage College

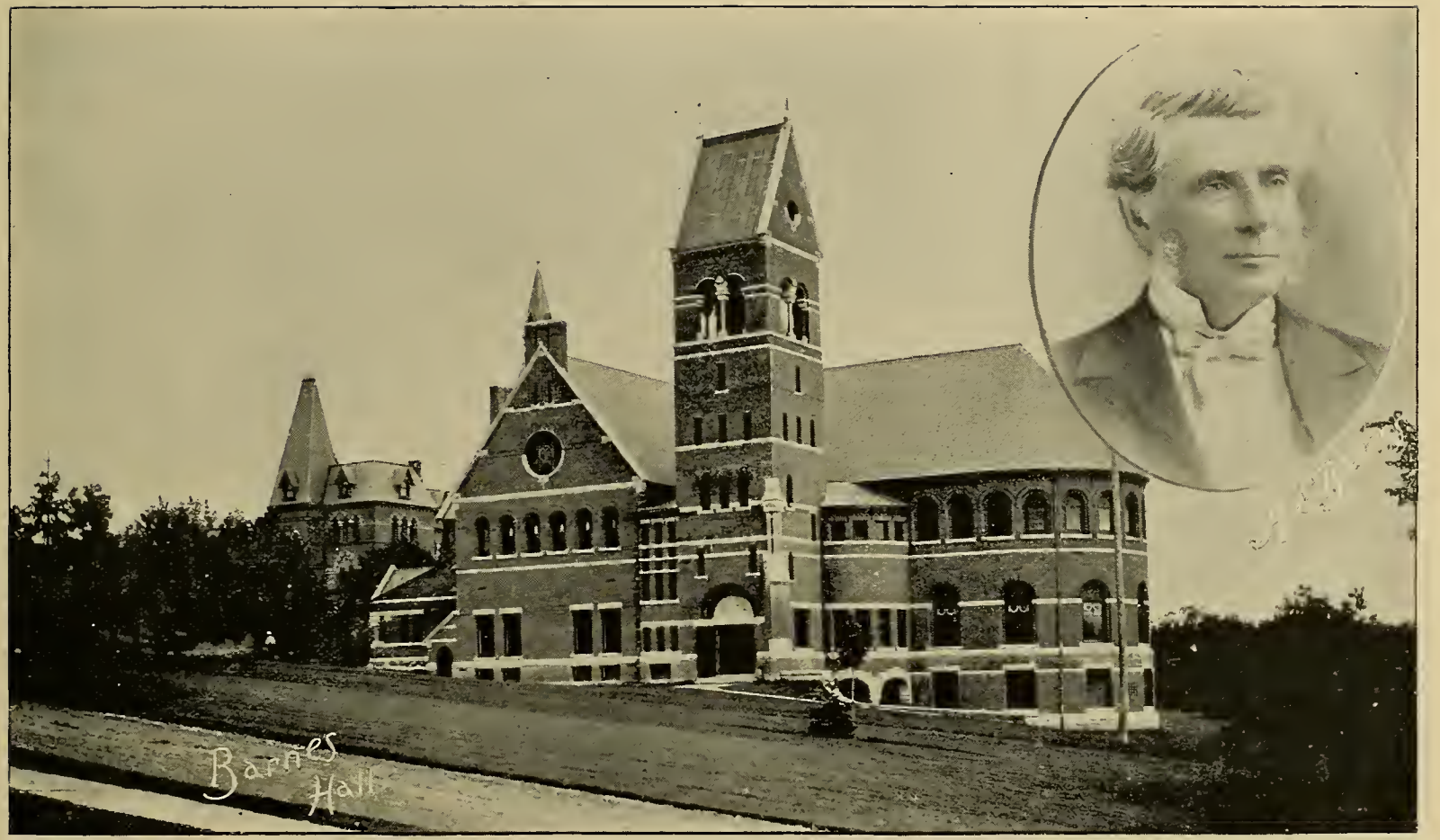
6. Botanical Department.

THE BOTANICAL DEPARTMENT is located in the south wing of Sage College. The lecture room has a seating capacity of about two hundred. There are two laboratories, one for Phanerogamic, the other for Cryptogamic work. The museum and Cryptogamic laboratory are on the second floor. The apparatus, storage, duplicate, pressing, and drying rooms are on the third floor. The laboratories are supplied with work tables, simple and compound microscopes, and reagents and apparatus for histological and physiological work. Some fifteen thousand species of plants are represented in the general herbarium. In the museum are found woods, cones, barks, fibers, oils, gums, fruits, and various vegetable products in alcoholic and dried specimens. Among other facilities for instruction and illustration are models, diagrams, charts, wall maps, and a stereopticon with some five hundred views of plants, and their parts, and the vegetation of different countries. Connected with the laboratory are the conservatories, consisting of a range of five plant houses. These supply at all times living plants for use in the laboratory and lecture room. Ten courses of instruction are offered, a general course extending through the year being followed by more special courses, which, in turn, are followed by opportunities for individual work and investigation. Professor A. N. Prentiss is at the head of the department.


The Conservatory
Prof. Prentiss

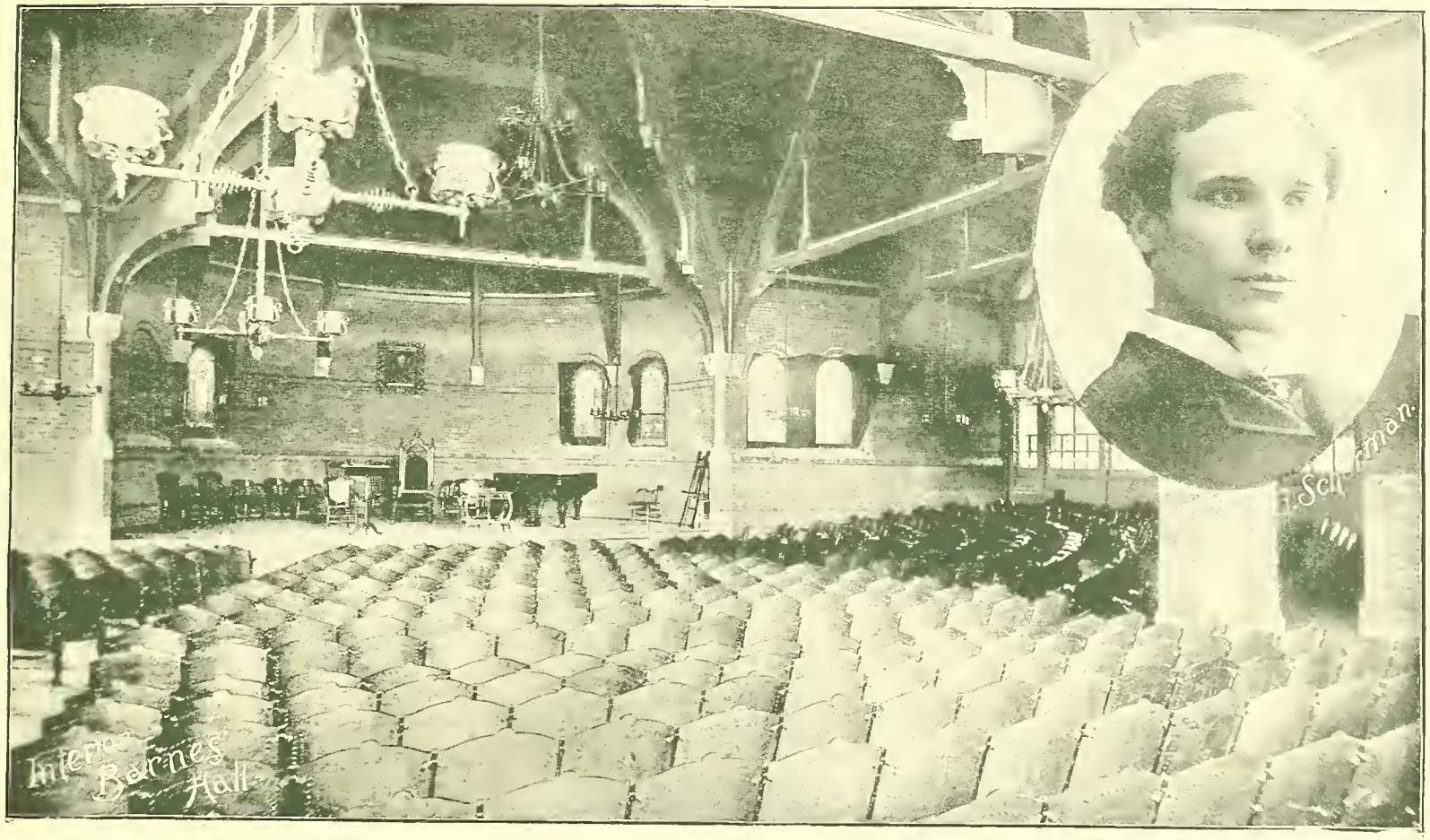
7. Barnes Hall.

BARNES HALL is the special abode of the students' Christian Association of Cornell University. The building was given to the University by Mr. A. S. Barnes, the eminent publisher of New York, for the purposes of the Christian Association and such other uses of the University as might not conflict with the needs of the Association. The dimensions of the building are one hundred and twenty by eighty feet. The tower rises to a height of one hundred feet. The material is brick, with trimmings of Ohio stone, brown stone, and granite. The building contains a secretary's room, two assembly-rooms, a library, a reading room, and all other needed accommodations for the work of the association. While the building is warmed with steam, the library and several of the smaller rooms are furnished with fire-places for purposes of more complete ventilation. Through the generosity of General A. C. Barnes, a library has been furnished the Christian Association, consisting of nearly one thousand volumes of works most needed for reference and the modern methods of Biblical study. In the periodical room some thirty periodicals and journals are constantly on file. In 1890-91 the Cornell Students' Christian Association has a membership of five hundred and forty-one.


Barnes Hall

8. Interior of Barnes Hall.

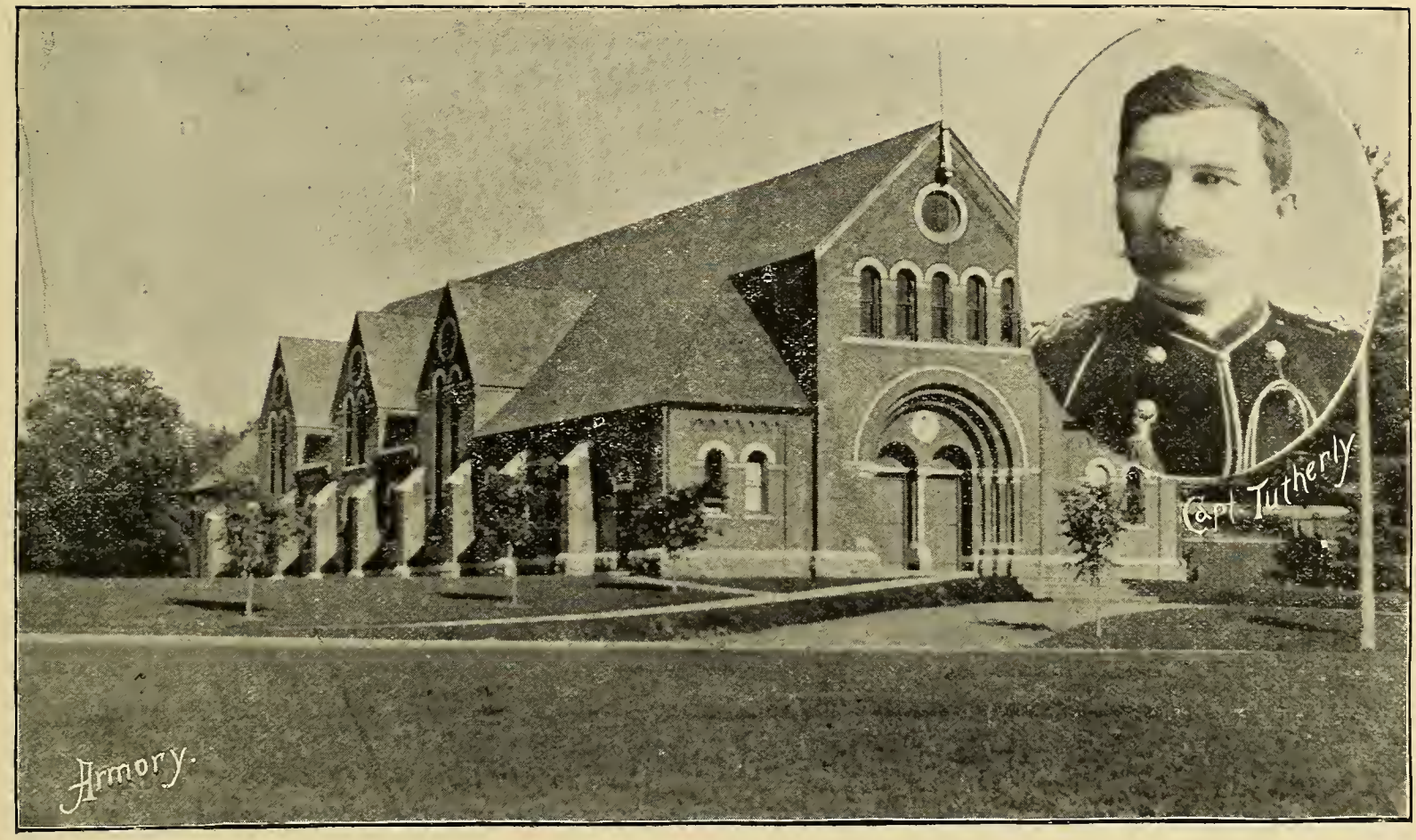
THE VIEW on the opposite page shows the auditorium of Barnes Hall, in which many of the lectures in history, English literature, and other branches are delivered. In this hall and in the room adjacent is given a considerable part of the instruction in the Sage School of Philosophy. This school, founded by a gift of two hundred and seventy thousand dollars by Mr. Henry W. Sage, and a supplementary appropriation of nearly the same sum by the University, consists of the most complete facilities for the study of the various branches of philosophy and ethics. The corps of instruction consists of a Professor of Philosophy, a Professor of Pedagogy, a Professor of Psychology, a Professor of the History and Philosophy of Religion and of Christian Ethics, two Assistant Professors, and one Instructor. It is announced that the school will be fully equipped before the beginning of the college year 1891–92. The material equipment of the school, besides the necessary rooms for lectures and instruction, will comprise the requisite seminary rooms and the most complete facilities for carrying on investigations in Physiological and Experimental Psychology. Professor J. G. Schurman is Dean of the school.


Interior Barnes' Hall
Schumann

9. The Military Department.

THE CONGRESSIONAL enactment of 1862, from which a portion of the University funds was derived, requires instruction in military tactics; and an officer of the United States Army is stationed at the University as military professor. Required drill is confined to the freshman and sophomore classes, though the upper classes usually supply the commissioned officers. The "*Armory and Gymnasium*" is a model building in plan for its dual purpose, though an extension has recently been provided for to meet the increasing number of students, which has more than doubled since its construction in 1883. The National Government supplies arms, equipments, and ammunition, and a neat, inexpensive uniform is worn during drill. The military organization in 1890-91 aggregates 541 Cadets, and comprises a regiment and a separate company of Infantry, an Artillery platoon, and a military band. Instruction is so conducted as to develop a soldier-like bearing and foster the spirit of gentlemanly courtesy and obedience, as well as to familiarize students with drill regulations.

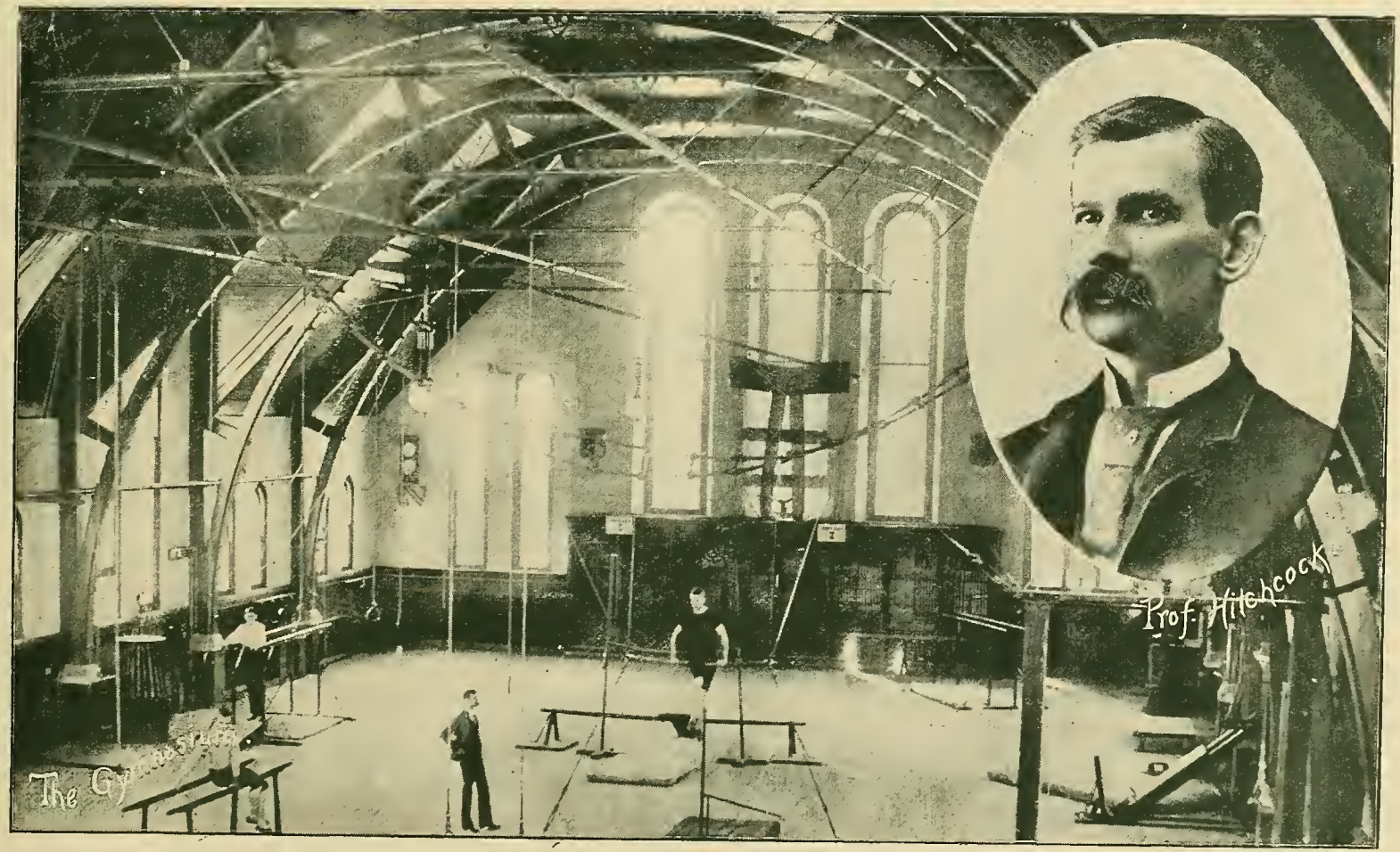
There is a brief course in Military Science, and graduates who have shown special aptitude for military service are given a Military Certificate, and are also reported to the War Department and State Government, and the names of the three most distinguished, in military science and tactics, are published in the "Army Register." Capt. H. E. Tutherly is at the head of the department.


Capt Tutherly.
Armory.

10. The Gymnasium.

THE view shows the east half of the Main Hall, a room one hundred and fifty feet long, sixty wide, and forty high, lighted by electricity, and heated by steam. Connected with it by a short corridor are the offices of the Department, dressing, bath, and repair rooms. The gymnasium is well equipped with modern appliances for the carrying out of prescribed exercises for individuals as well as with a full supply of all the ordinary kinds of apparatus for class work. Here every working day throughout year, Saturdays excepted, the Asthenic Class assembles for instruction. This class is composed of students from all Departments of the University, who, in the physical examinations made by the director, are found to be physically deficient. These meet with the Instructor for exercise apportioned to their needs. Here, too, under his supervision, these same students carry out the exercises prescribed at the office for the remedying of their individual deficiencies. In the Winter term are held the class exercises of Freshmen and Sophomores as required by the University.

At the annex, in Sage College, is the Gymnasium for women, where each working day throughout the year, excepting Saturdays, required exercises are conducted by the Director. These exercises are mainly those known as Light Gymnastics. The Professor of Physical Culture is Edward Hitchcock, Jr., M. D.


Prof. Hitchcock

11. The General Museum of Natural History.

THE VERTEBRATE division of the museum includes animals from man to fishes. Though no attempt has been made to obtain all of the many thousand species, certain forms have been selected, prepared, and arranged to illustrate important facts or principles of structure, function, development, and relationship. For example, of the two thousand living mammals, a fair idea of the appearance and habits of all may be gained from the single case where are placed twenty species with anatomical preparations displaying the features that lead zoologists to associate creatures apparently so unlike as whales and bats, monkeys and seals.

In the arrangement and increase of the museum, its main purpose as an essential adjunct to instruction has never been lost sight of. Its characteristic features are: First, the large number of preparations of the heart and brain, and of embryos; and secondly, the perfection of individual specimens. A special effort has been made to illustrate the development of species both by a series of embryos and by preparations exhibiting the anatomical resemblances between the various orders of the animal creation. Quality, not quantity, has constantly been aimed at; yet the museum contains a vast number of objects of general interest, including nearly, if not quite, all the birds and fishes of this vicinity. Professor B. G. Wilder is the Professor of Physiology and the Curator of the Museum.


Museum of Nat. History.
B. Wilder

12. Physiology and Vertebrate Zoology.

THE ACCOMPANYING illnstration gives a view of the room in which a large part of the instruction in this department is given. It consists of two general courses of lectures, four special courses, and two advanced conrses. In Physiology, the brain and organs of sense are treated with a view to prepare students for the course on the Morphology of the brain and for Psychology. The lectures are given in the room shown in the cut, and are illustrated with a manikin and a variety of other models, by specimens and diagrams, and by painless experiments. All the members of the class are put to the practical work of dissecting cats, sheeps, brains, eyes, and hearts, as well as to the careful examination of microscopic preparations. In Vertebrate Zoology the several groups and classes are illustrated with the aid of specimens and diagrams, and students are put to the study of representative forms by dissection. The special course on the Morphology of the Brain is designed to afford opportunity for the most careful study. In the remaining five courses, while lectures are given, the main stress is laid upon the work done in the laboratory by each student in the application of the most approved methods and in the use of the best and latest literature of each subject. In the two advanced courses abundant opportunity is offered for research in human and comparative anatomy, histology, and systematic zoology. The work of the department is peculiarly adapted to the needs of students intending to study medicine as a profession. Professor S. H. Gage is in charge of Microscopical Technology.

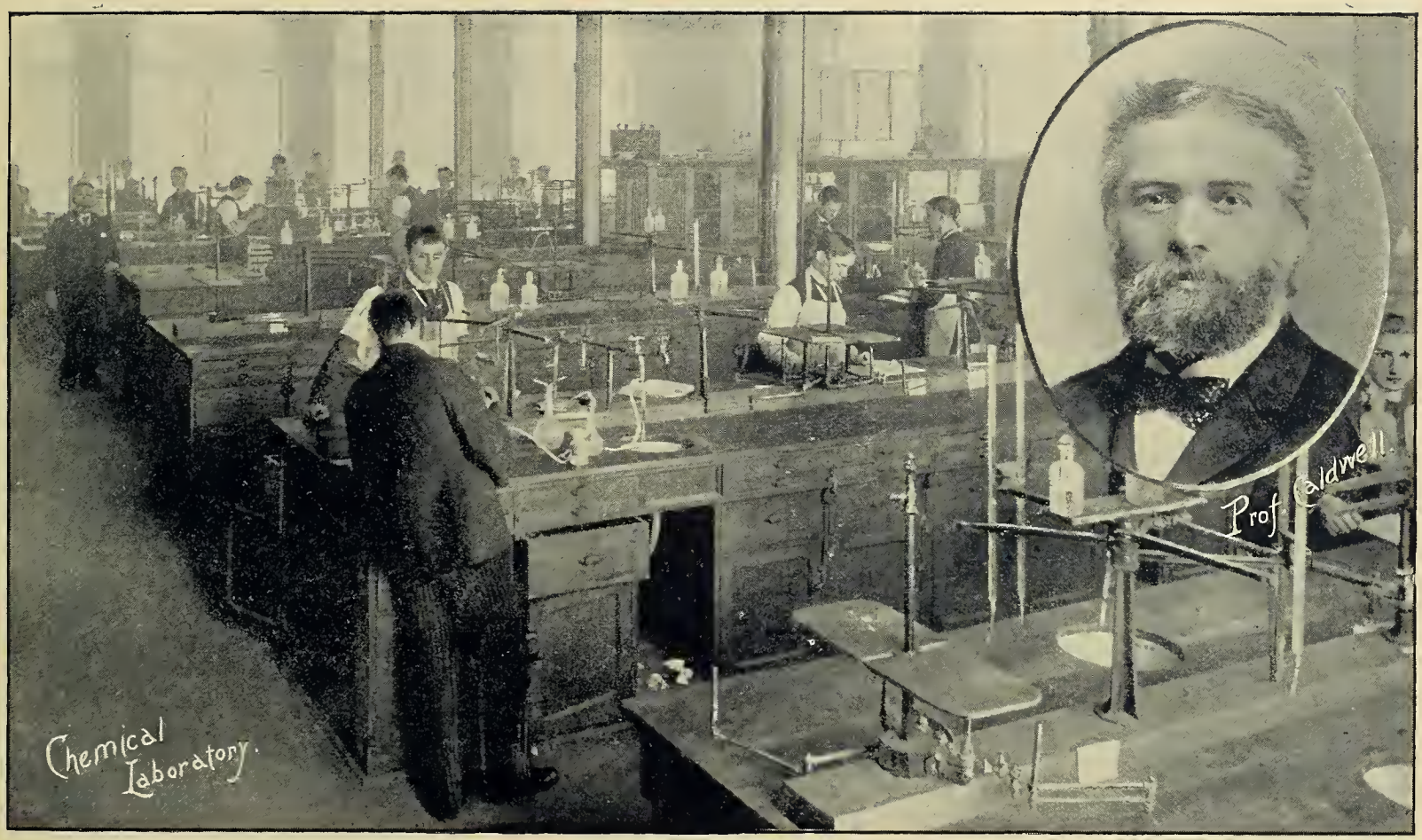

Physiological Lecture Room.
Prof. Gage.

13. The Chemical Laboratory.

MORSE HALL, a brick building of a plain but dignified style of architecture, erected in 1889–90 for the exclusive use of the chemical department, commands from its west windows the finest of all views of the valley, lake, and hills beyond.

Built in the so-called Mill construction method, it is as nearly fire-proof as any building can be that is not made altogether of incombustible materials. In order that all the rooms may be as light as possible, the walls are really only piers between the windows of exceptionally large size.

The building contains fifty rooms. In the basement, which is as well lighted as any other part, are situated the qualitative and organic laboratories. The first floor is devoted almost entirely to instruction in quantitative analysis; while on the third floor, besides several small rooms, are located a great lecture room for general chemistry, a large student laboratory for beginners, and the chemical museum. The senior officer in the department is Dr. G. C. Caldwell, Professor of Analytic and Agricultural Chemistry.


Chemical Laboratory.
Prof Caldwell.

14. The Department of Chemistry.

THE LARGE lecture room of the chemical laboratory has three hundred and fifty-two seats, and in all the laboratories together there are places for six hundred students working simultaneously. Reservoir water and gas are supplied at each student's place, and distilled water, oxygen, hydrogen, air-blast, and suction are conveyed in pipes to every room where needed. Special supplies of chemicals or apparatus are drawn by the students as wanted, from the general supply room on the first floor, conveniently accessible from all parts of the building. Accessible to all students in one of the rooms on the first floor is a reference library of fourteen hundred volumes, comprising complete sets of all the important chemical journals, and a large number of other works, old and recent, relating to all branches of chemistry.

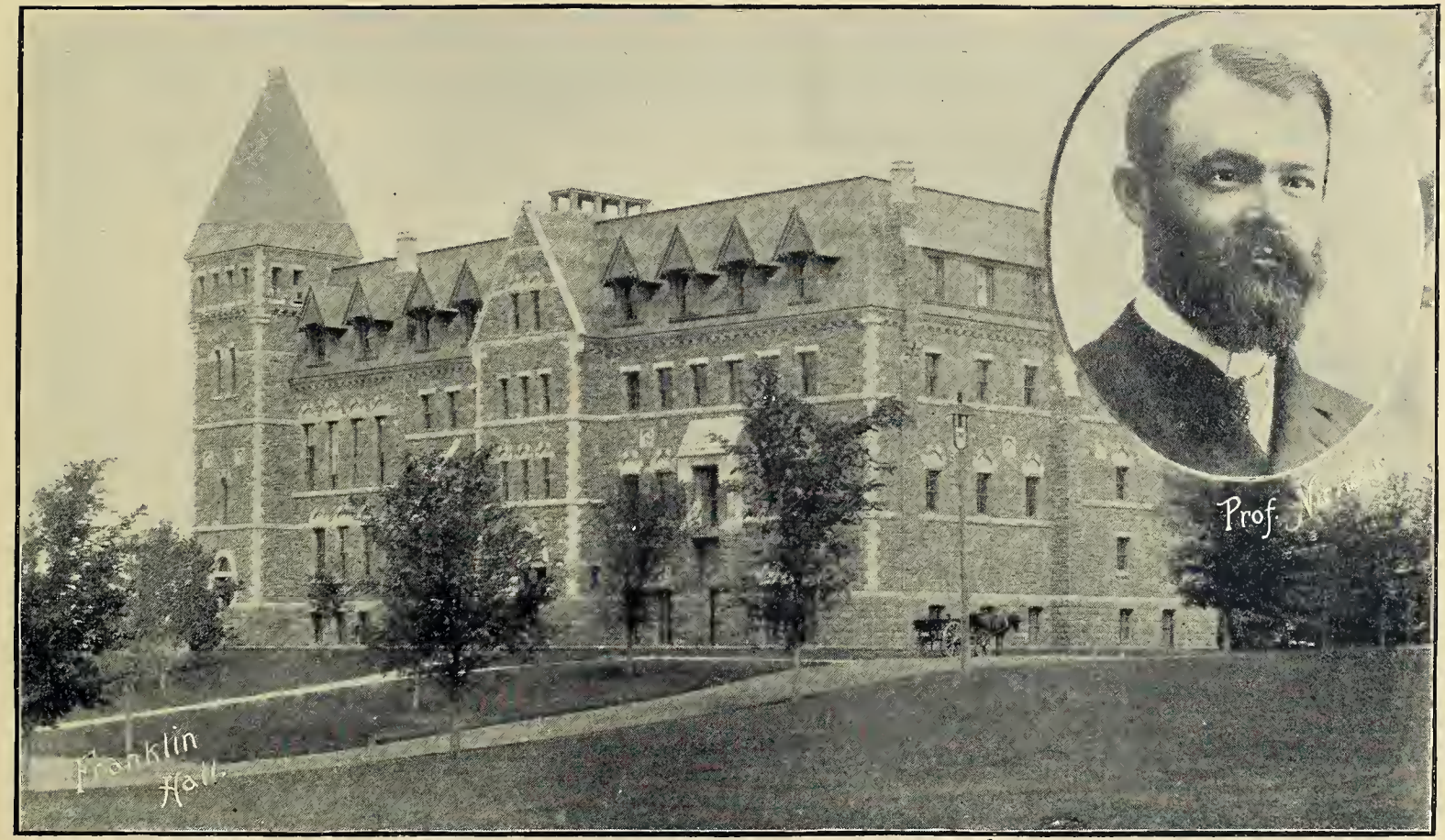
The teaching force of the chemical department consists at present of nine professors and instructors. These give instruction in both the lecture room and the laboratory, in general chemistry, qualitative and quantitative analysis, and in organic chemistry, and, besides, in special branches of work in special rooms devoted to these purposes, such as gas, iron, water, sanitary and spectroscopic analysis. Dr. S. B. Newbury is Professor of General and Organic Chemistry.


Chemical Lecture Room
Prof. Newberry

15. The Laboratory of Physics.

THE BUILDING exclusively occupied by the Department of Physics is called Franklin Hall, "In honor of the first American electrician," whose head in terra-cotta bas-relief adorns the door-way.

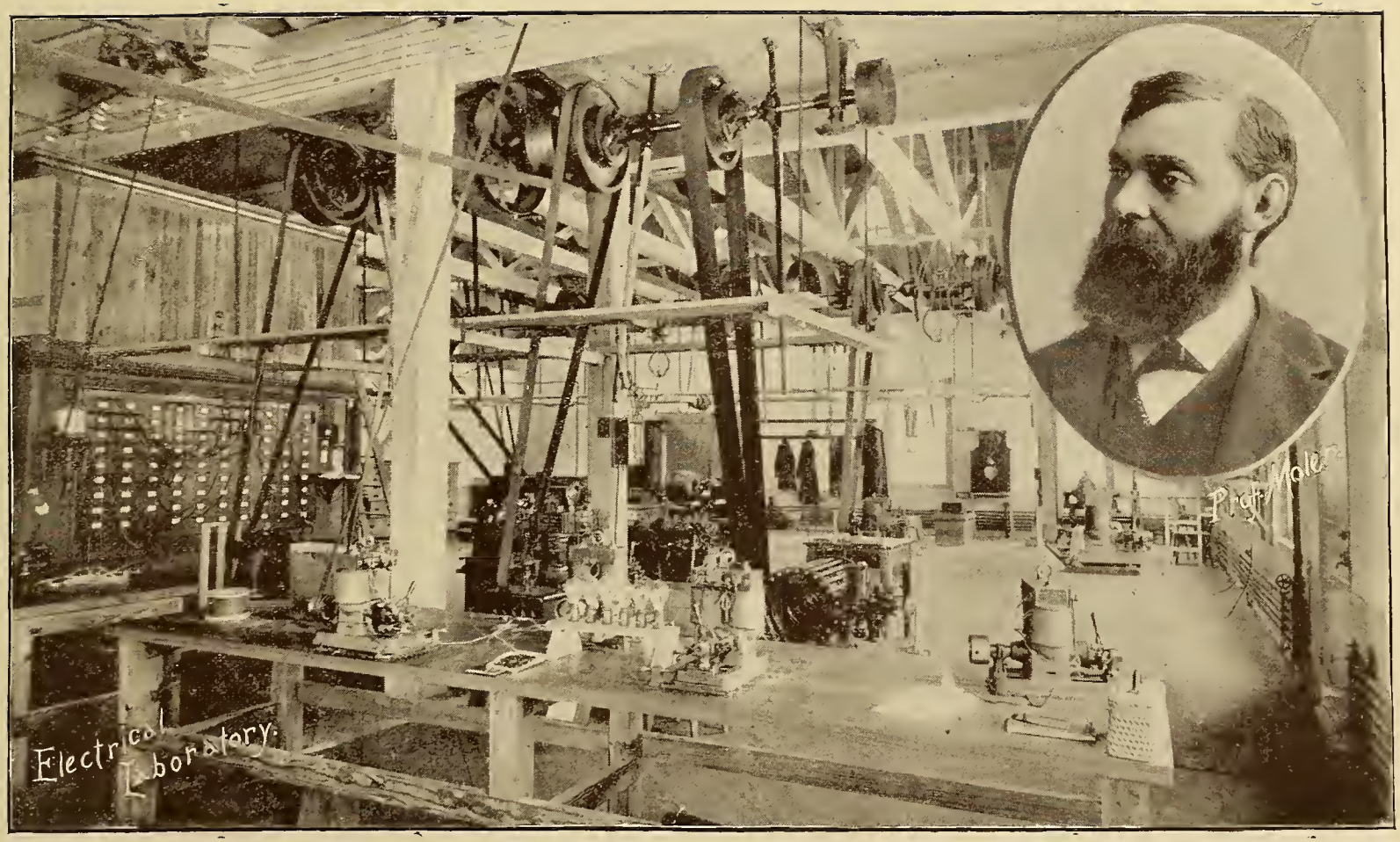
At the time of its erection in 1883, Franklin Hall, which was designed as a physical and chemical laboratory combined, was deemed ample for the accommodation of both departments. At the present time, however, the entire building is given over to the study of experimental physics. On the first floor is the large lecture room especially equipped for demonstrations. It is here that the student begins his acquaintance with the science which, if he be an engineer, will occupy more or less of his time during three years of his college course. Besides other recitation rooms, the cabinet of apparatus occupying three large rooms adjoining the lecture room, and the laboratories for practice work in general physics, applied electricity, photomety, and practical photography, Franklin Hall contains many rooms where original investigation can be carried on. Research, indeed, is regarded as a very important feature of the work of the department, and it forms an essential element in the training of all advanced students in physics. Such students come to it well equipped after a year of lectures and recitations, a year in the junior laboratories, and a year of more difficult work in heat and applied electricity. At the head of the department is Professor E. L. Nichols.


Franklin Hall.
Prof.

16. The Laboratory of Electrical Engineering.

THE DYNAMO LABORATORY, of which a view is shown on the opposite page, is believed to be the largest college dynamo-room in this country, if not in the world. It contains no machines that are used in regular lighting service, but is devoted entirely to the experimental study of dynamos and motors. The floor space is 40 x 70 feet; there are three lines of main shafting overhead that are driven by steam and water power. The collection of dynamos includes nearly all the well known commercial types, together with many machines of unusual form, constructed especially for experimental purposes. These machines are of various sizes, from twenty horse-power down, and they are arranged with special reference to the requirements of experimental work.

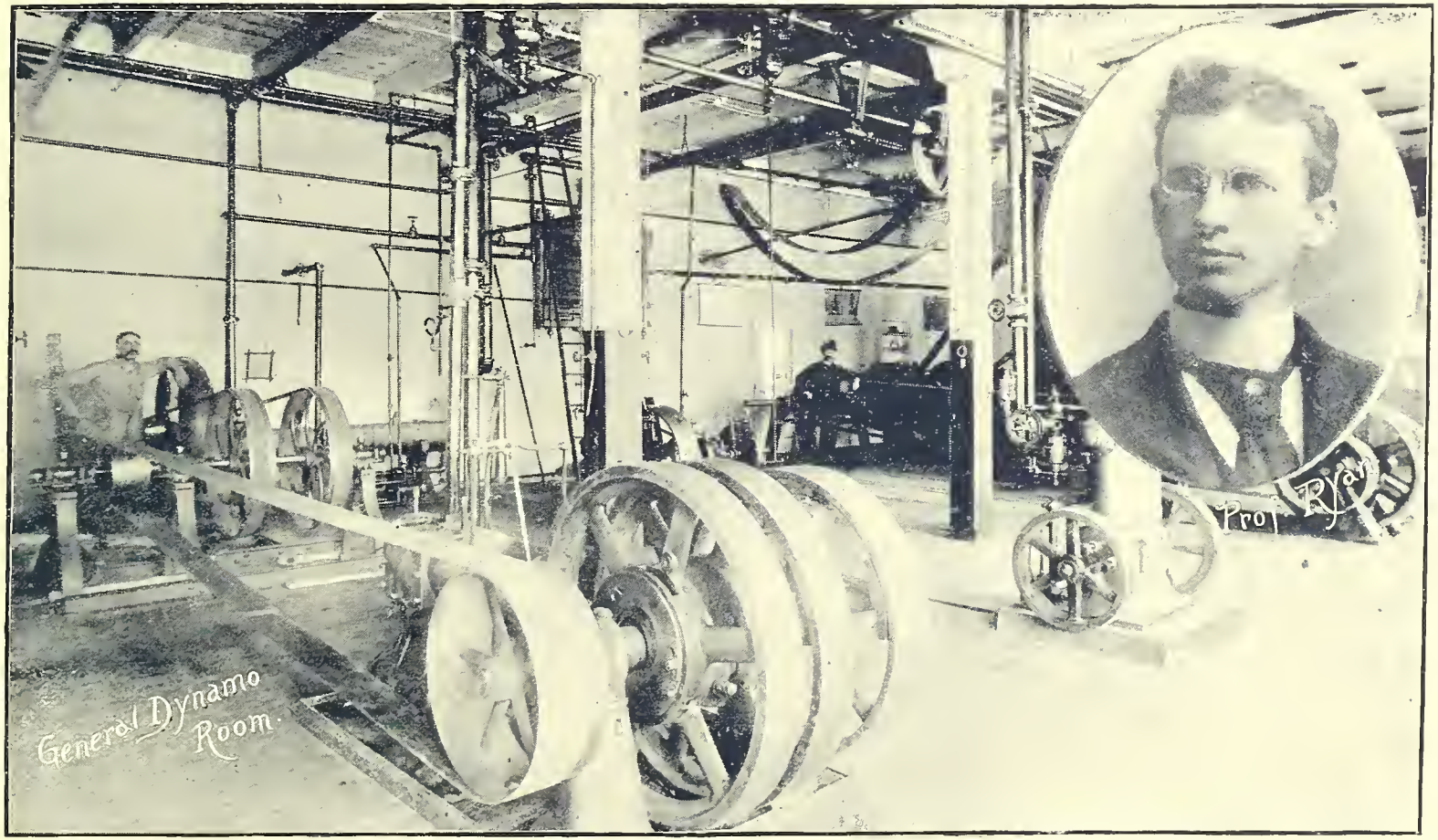
An important part of the work in applied electricity, the measurement of currents and electromotive forces, together with a detailed study of storage batteries, arc-lamps, voltameters and electric meters, is carried on in the annex to Franklin Hall, which is a substantial one-story building 100 x 37 feet. Operations of extreme precision are conducted in the Magnetic Observatory, an isolated building entirely free from iron, which contains the great galvanometer and other standard instruments for measuring current and potential, and the magnetic elements. Professor G. S. Moler is in charge of this laboratory.


Prof. Mailer
Electrical Laboratory.

17. The University Lighting Dynamo Room.

THE DYNAMOS that are used for University lighting, herewith shown, are arranged to be operated with the greatest economy and satisfaction, as well as to afford opportunity for complete "plant" testing by students of electrical engineering. They have been placed in the steam-engine laboratory in the closest proximity to the sources of water and steam power. For the incandescent lighting of shops, laboratories, and offices, current is obtained from an Edison five hundred light dynamo, a gift to the University by Mr. Edison. Arc-lamps in shops and armory, and on the campus, are supplied with current from a forty-arc light alternator, presented to the University by the Westinghouse Electric Company.

The dynamos are so installed that they may be driven by water or steam power, or both. Ordinarily they are operated by water power, furnished by the turbine water wheel in the Ithaca Gorge, and are driven from the shop main-line shaft by belting through a jack-shaft. This connection to the line shaft is made automatically when the machines are to be started so that the line shaft does not have to be stopped. The jack-shaft is equipped with friction-clutch pulleys of the most approved make, enabling each machine to be started and stopped independently. A Straight-Line Automatic engine is so arranged that it can be belted to the jack-shaft at any time without stopping, and is thus used ordinarily to help the water-power over the maximum demand for power in the shops and for lights that occurs between five and six o'clock. The dynamo room is in charge of Professor H. J. Ryan.

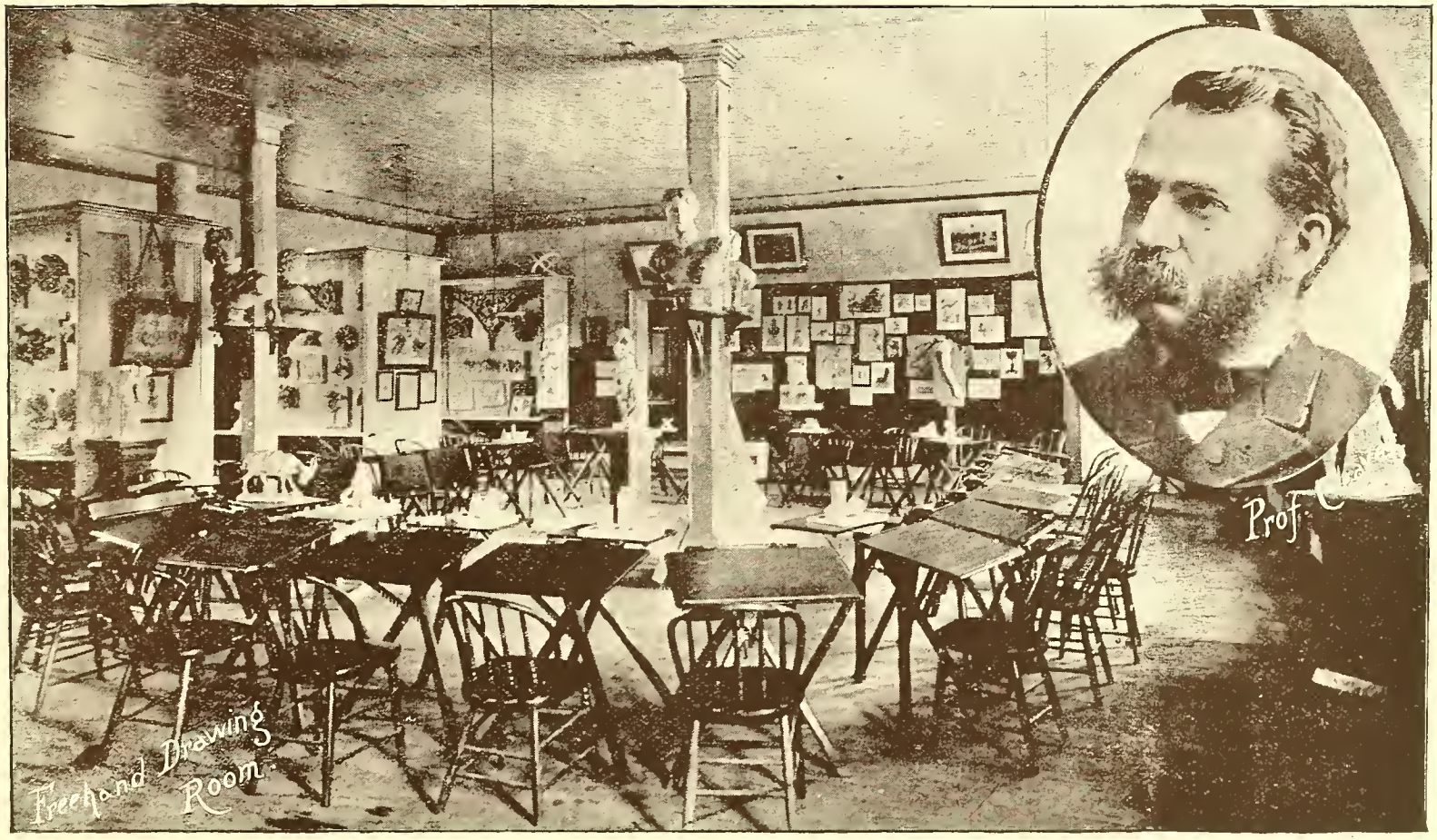

General Dynamo Room.
Prof. Ryan

18. Industrial Drawing and Art.

THIS DEPARTMENT occupies four rooms, constituting the whole upper floor and part of the second floor of the main building of Sibley College, and supplies instruction in drawing, both industrial and artistic, not only to the technical classes of the college, but also to all the other departments of the university. Only one of the four rooms is shown in the illustration. It has a most excellent equipment in casts, drawings, and other works of art, and a great variety of studies in engineering and architectural work. This equipment is continually growing at a rapid rate, and will be held at all times fully up to the demands made upon it by the classes of both sections of its work. The courses taught include a complete series of studies in Industrial Art and accessory work, and provision is made for the instruction of individuals desiring special work in free-hand drawing, or water color and oil painting. In the warm season, out-of-door classes are formed, and in the winter, classes of students in art take up figure-drawing from models, and from casts selected with care for the purpose.

Among the collections of this department may be seen many illustrations of the skill attained by pupils, in all stages of progress, from the novice taking up the work for the first time, to the artist in the full swing of professional success.

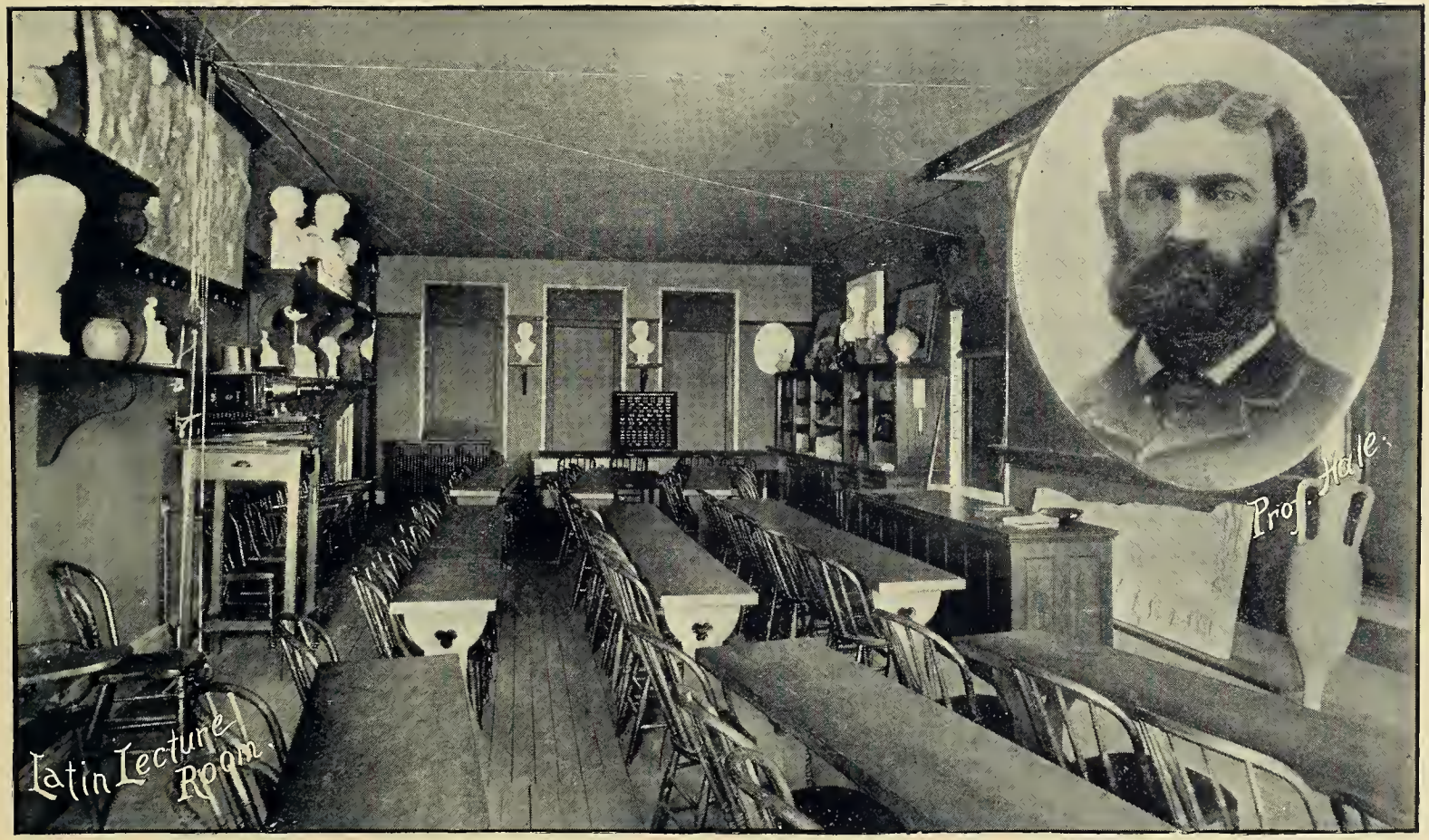
Though the system of instruction in mechanical drawing is exceptionally complete, it is subject to frequent revision, and the studies and exercises are regularly reconstructed each year. Professor E. C. Cleaves is in charge of this department.


Freehand Drawing Room
Prof

19. The Department of Latin.

THE ILLUSTRATION represents the principal lecture-room of the department of Latin, in which the illustrative material belonging to the department is kept, as follows: casts, reproductions of coins, a series of thirteen hundred photographs, and a collection of antiquities, made by the Professor of Latin, in Italy, embracing inscriptions, cinerary urns in marble, glass, and terra cotta, votive offerings and figurines, vases, terra cotta plaques, dishes for table use, lamps, ointment and perfume bottles in glass, bronze utensils and ornaments, a series of bronze coins giving portraits of most of the Roman Emperors, etc., etc. The aims of the department may be outlined as follows:

1. To teach students of fair ability and industry to read Latin understandingly and rapidly, without the delay of translating. 2. To give to students who acquire this power opportunities for the reading of considerable quantities of the literature, and for collateral reading in Roman History and the History of Roman Literature. All the more important authors not covered in the preparatory work are read, namely Horace, Livy, Terence, Plautus, Lucretius, Catullus, Pliny the Younger, Tacitus, and Juvenal; and, in addition, something more is read in Cicero. 3. To afford a more thorough and sympathetic knowledge of Roman Private Life than the courses in the literature alone could give, through systematic lectures, illustrated abundantly, partly by the collections described above, but mainly by lantern views and photographs from the remains of Roman civilization preserved in Pompeii, Herculaneum, and Rome. 4. To give to students whose interest extends to the scientific side of the language advanced work, by seminary methods, in the study of syntax. 5. To offer special training to students who intend to become teachers, partly through lectures, partly through the holding of recitations in the field of the preparatory work, and partly through exercises in teaching conducted by the members of the class themselves, under the direction and criticism of the professor. The corps of teachers consists of Professor W. G. Hale, an Assistant Professor, and an Instructor.


Latin Lecture Room.
Prof. Hale.

20. Greek and Comparative Philology.

THE GREEK DEPARTMENT offers unusual advantages not only for undergraduate, but also for advanced and graduate students. The work required of students in Arts is directed towards cultivating the ability to read easily and at sight, and towards giving the student some acquaintance with the scope and meaning of Greek literature and with the characteristics of Greek life and thought. For the year 1890–91, there are open to the choice of advanced students in Greek and Philology ten different courses of study, the most of which are given in the lecture room herewith represented. The Philological Seminary room with its library of 800 books of reference is open to the unrestricted use of graduate students and such undergraduates as are engaged in special investigation. It forms for such students a regular study-room or laboratory. This, with the exception of such objects of illustration as casts, photographs, and lantern-slides, forms the chief equipment of the department. The instruction of classes in antiquities, art, and literature is assisted by the use of the lantern. The number of candidates for advanced degrees (A. M. and Ph. D.) who are taking their major work in this department is disproportionately large; in 1890–91 being ten per cent. of all such in the university. The corps of instruction consists of Professor B. I. Wheeler, an Associate Professor, and an Instructor.


Greek Lecture Room.
Roy Wheeler.

21. The Historical Seminary Room.

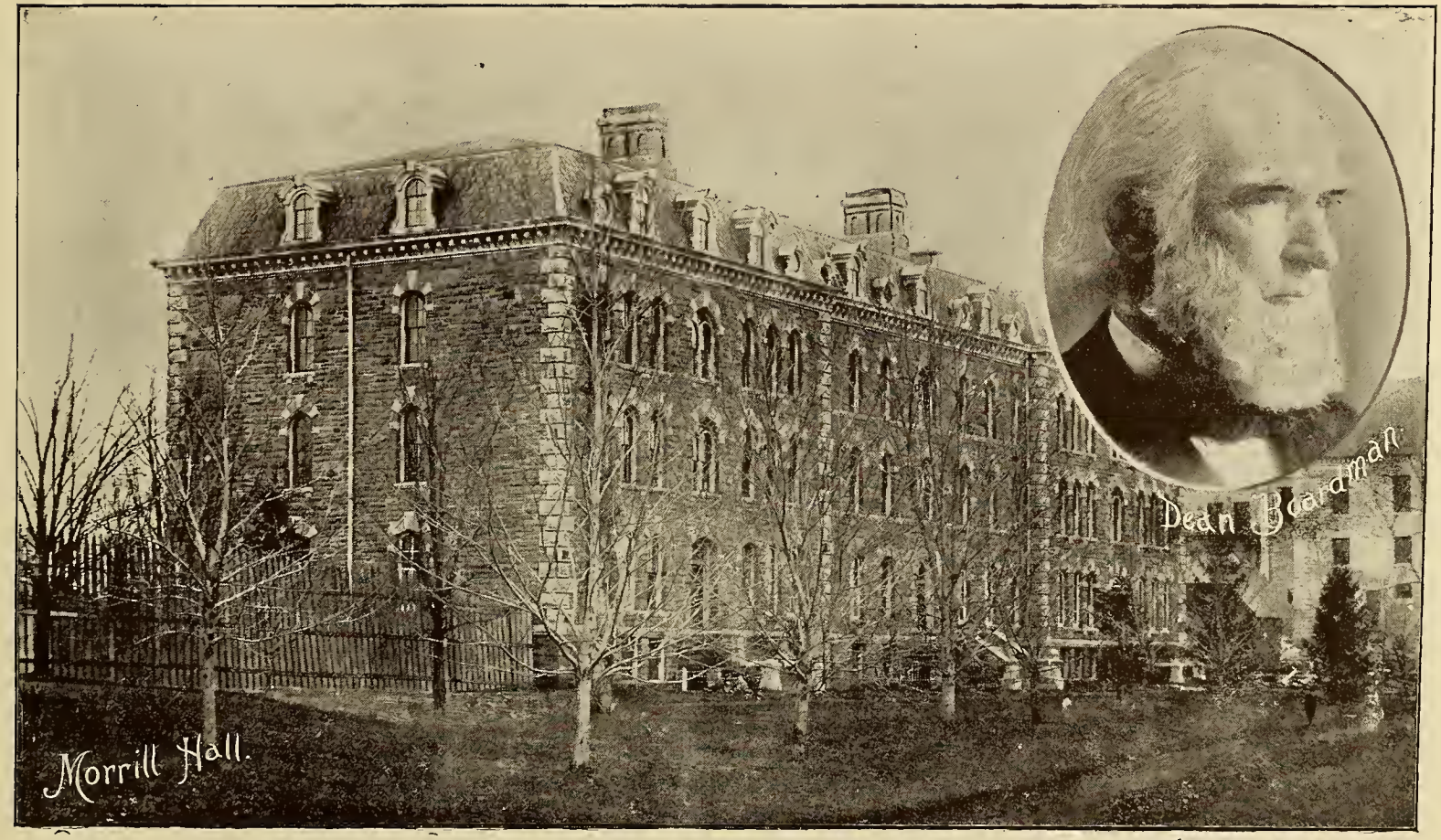
ON THE opposite page is a view of the working room of advanced students in the President White School of History and Political Science. It is here that a large part of the graduate work of the pupils of Professor Moses Coit Tyler and of Professor Herbert Tuttle is carried on. The shelves of the room contain such original authorities as complete sets of the "Congressional Globe," the "Congressional Record," Hansard's "Parliamentary Debates," and other works necessary for the most careful study of modern and European history. Each student has immediate access to the shelves, and has a drawer in one of the tables in which his notes may be stored. The room is open from eight o'clock in the morning until ten at night. The School of History and Political Science, which for the present has its headquarters in this room, consists of a Professor of Modern History, a Professor of American History, an Assistant Professor of Ancient and Medieval History, a Professor of Political, Municipal, and Social Institutions, a Professor of Political Economy and Finance, and an Instructor in History. The new library building will furnish unsurpassed facilities for advanced study and investigation in connection with the President White Library. Professor Herbert Tuttle is Professor of Modern History.


Historical Seminary Room
Prof. Turner

22. Morrill Hall.

MORRILL AND WHITE Halls are buildings erected from the same plans for the accommodation of the various lecture, recitation, and seminary rooms that are called for in the general courses of instruction in the University. In these buildings instruction is given in Greek, Latin, French, German, Spanish, and Italian, as well as in political economy, history, English, mathematics, and some of the branches of natural history.

In the upper part of Morrill Hall are rooms set apart for the School of Law. This school, although organized only four years ago, consists of three professors and an assistant professor, who devote their entire time to the work of instruction, besides eight or ten non-resident lecturers of distinction who are more or less actively engaged in the work of their profession. In the fourth year after the organization of the school there were enrolled one hundred and twenty pupils. The library for the use of students consists of about seven thousand volumes. The growth of the school has been so rapid, and the demands for accommodations are so much greater than the building affords, that the trustees at a meeting in February, 1891, provided for the immediate erection of a new Law School building. The Dean of the school is the Honorable Douglass Boardman, for many years a Judge of the Supreme Court.

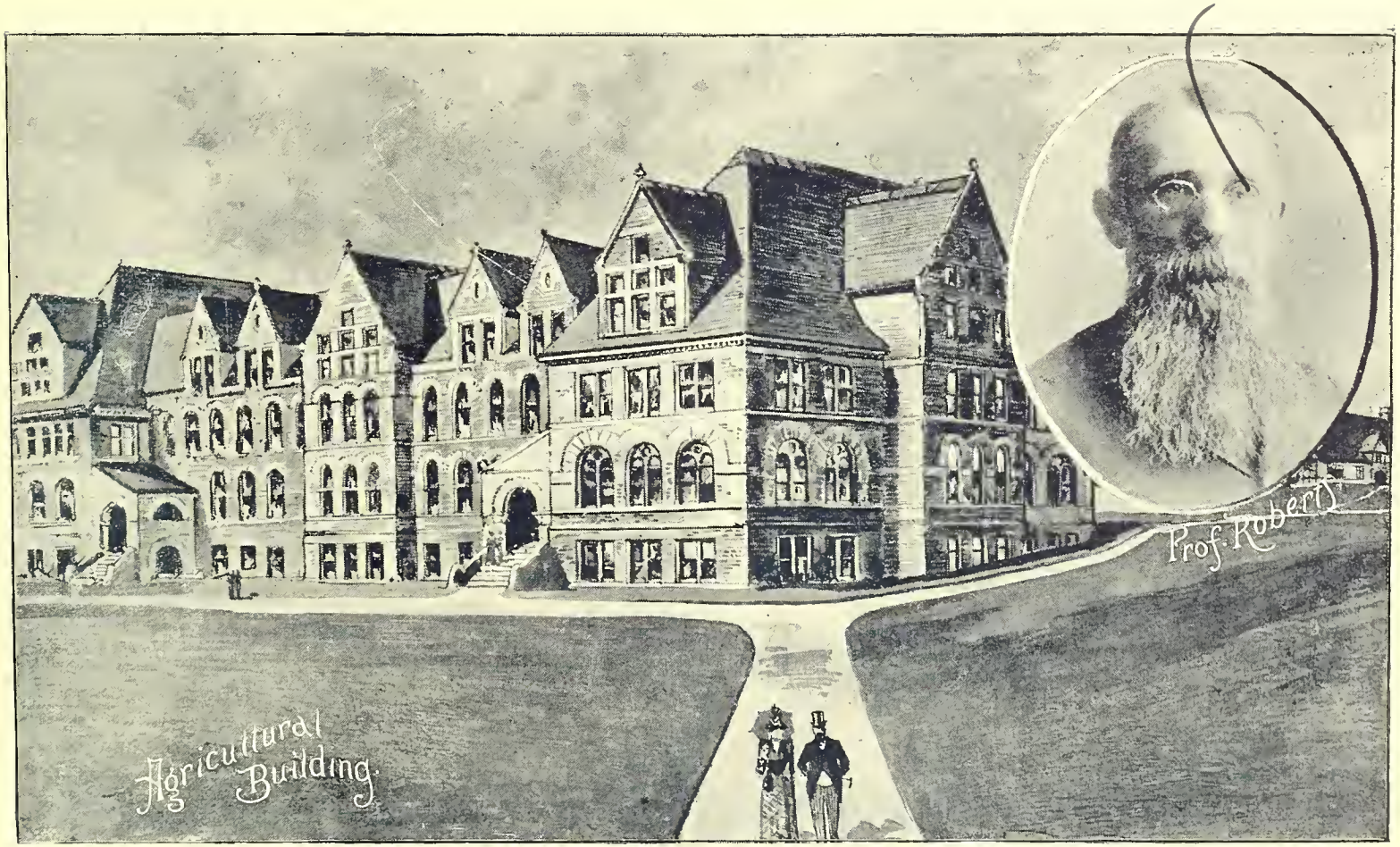

Morrill Hall.
Dean Boardman.

23. The College of Agriculture.

THE BOARD OF TRUSTEES have lately decided to appropriate eighty thousand dollars for the erection of a building for the use of the College of Agriculture and the experiment station. This building, of which a cut from the architect's drawings is given, when completed, will not only promote the work of each department, but will place at least four closely allied divisions of the college in the same building.

The structure will be about two hundred feet long, in shape somewhat like the letter H. The middle portion of the building, throughout the four stories, is given up to museum purposes, while the ends are subdivided into class-rooms and laboratories. The floor space will exceed 40,000 square feet, one third of which will be devoted to museum and cabinets of illustrative materials and station appliances. In the College of Agriculture two courses are open to students, known as the complete and special courses, the former leading to the degree of bachelor of science in agriculture. During the first two years the students are thoroughly grounded in the natural sciences, after which, in the last two years, instruction is given in agriculture, dairy-husbandry, veterinary science, agricultural chemistry, economic entomology, and horticulture.

Young men over eighteen years of age, having a good common school education, are admitted, without examination, to the special course. Such students may remain two years, and must select at least three fourths of their studies from the subjects named above. Professor I. P. Roberts is Director of the College.

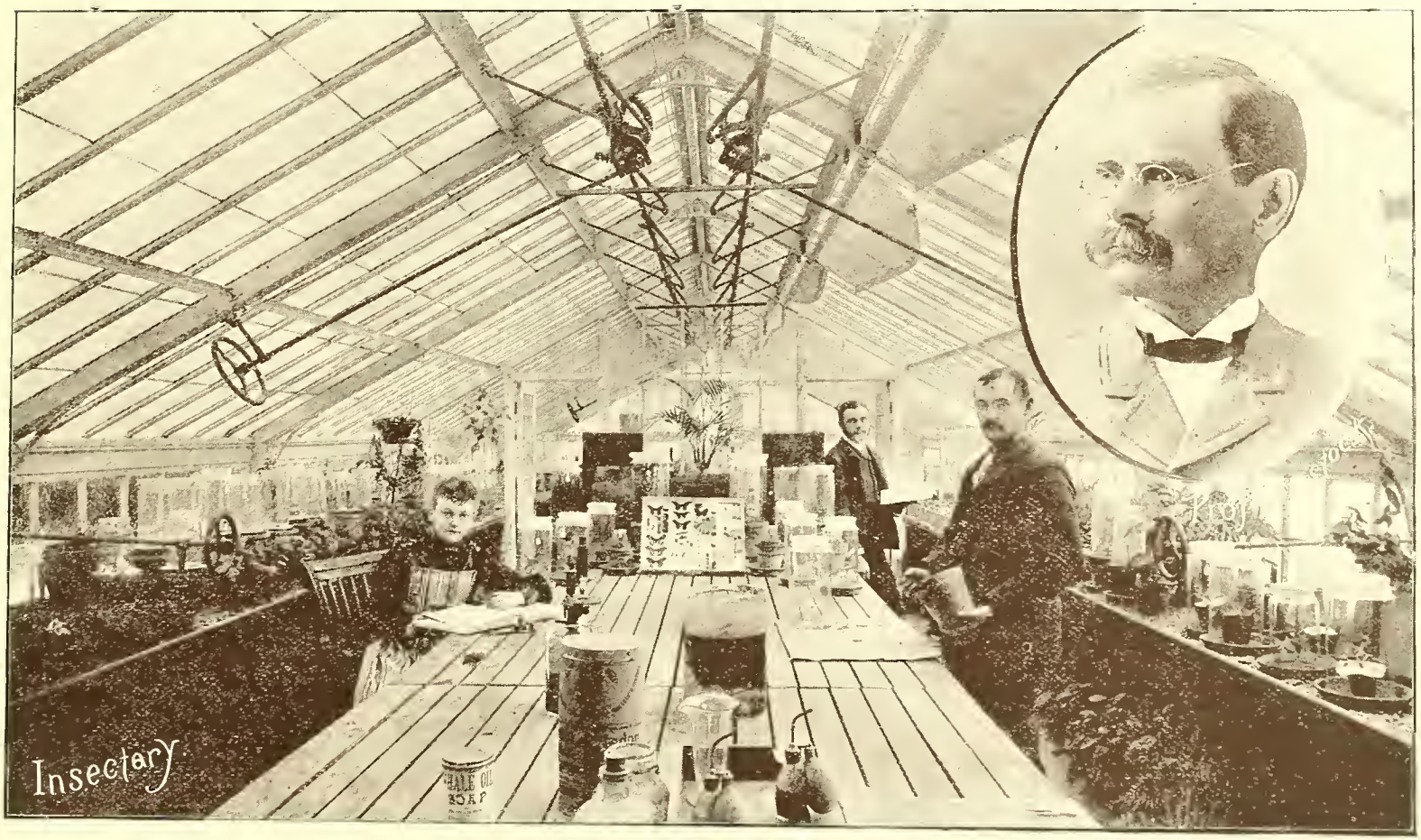

Agricultural Building.
Prof. Roberts

24. The Insectary.

THE INSECTARY was built to afford facilities for carrying on the entomological part of the work of the Agricultural Experimental Station. The characteristic feature of it is a conservatory in which plants are grown with living insects upon them. By this means the transformation and habits of the insects to be studied can be observed from day to day, and experiments for determining the best method of controlling their ravages can be carried on. Various forms of breeding-cages are in use, each adapted for a special purpose. By means of one of these the observer can watch the operations of insects feeding on the roots of plants without disturbing either the plants or the insects.

The cottage to which the conservatory is attached contains a laboratory, rooms for photographic purposes, a store room, quarters for an assistant, and, in the basement, a cold storage room for breeding cages containing hibernating insects.

Although the Insectary is primarily intended for the use of the Entomological division of the experiment station force, it is also used to some extent by the advanced students in the Department of Entomology, to supplement the work carried on in the Entomological rooms in White Hall. Professor J. H. Comstock is at the head of the department.

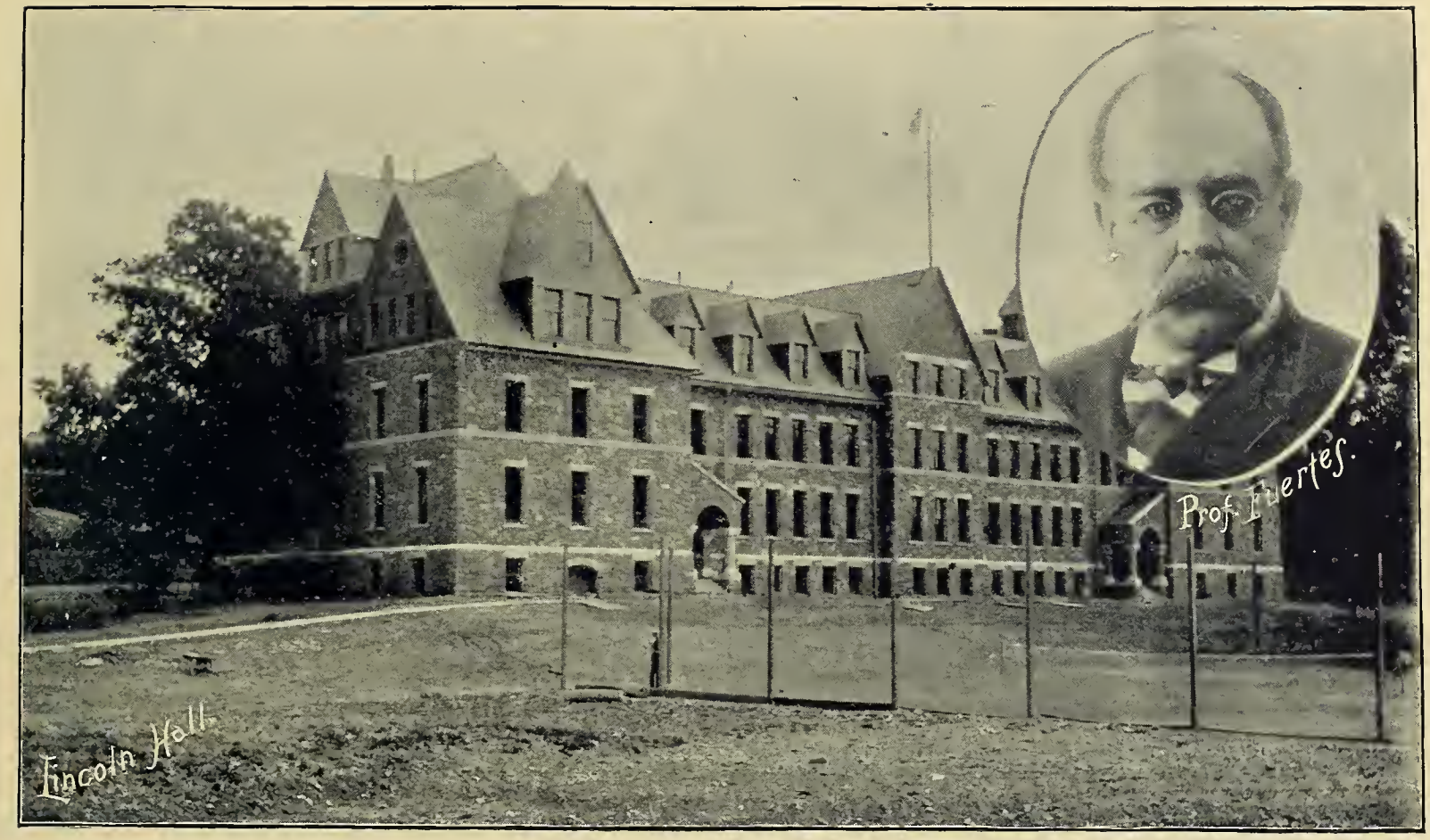

Insectary

25. The College of Civil Engineering.

THE QUARTERS of this college are in a red sandstone building known as Lincoln Hall, a structure two hundred feet long and seventy-two feet wide with a semi-basement and four working floors. The basement contains ten engineering laboratories besides rooms for the Superintendent, Mechanician, and a fair sized auditorium. These rooms are crowded with machines and apparatus in constant use.

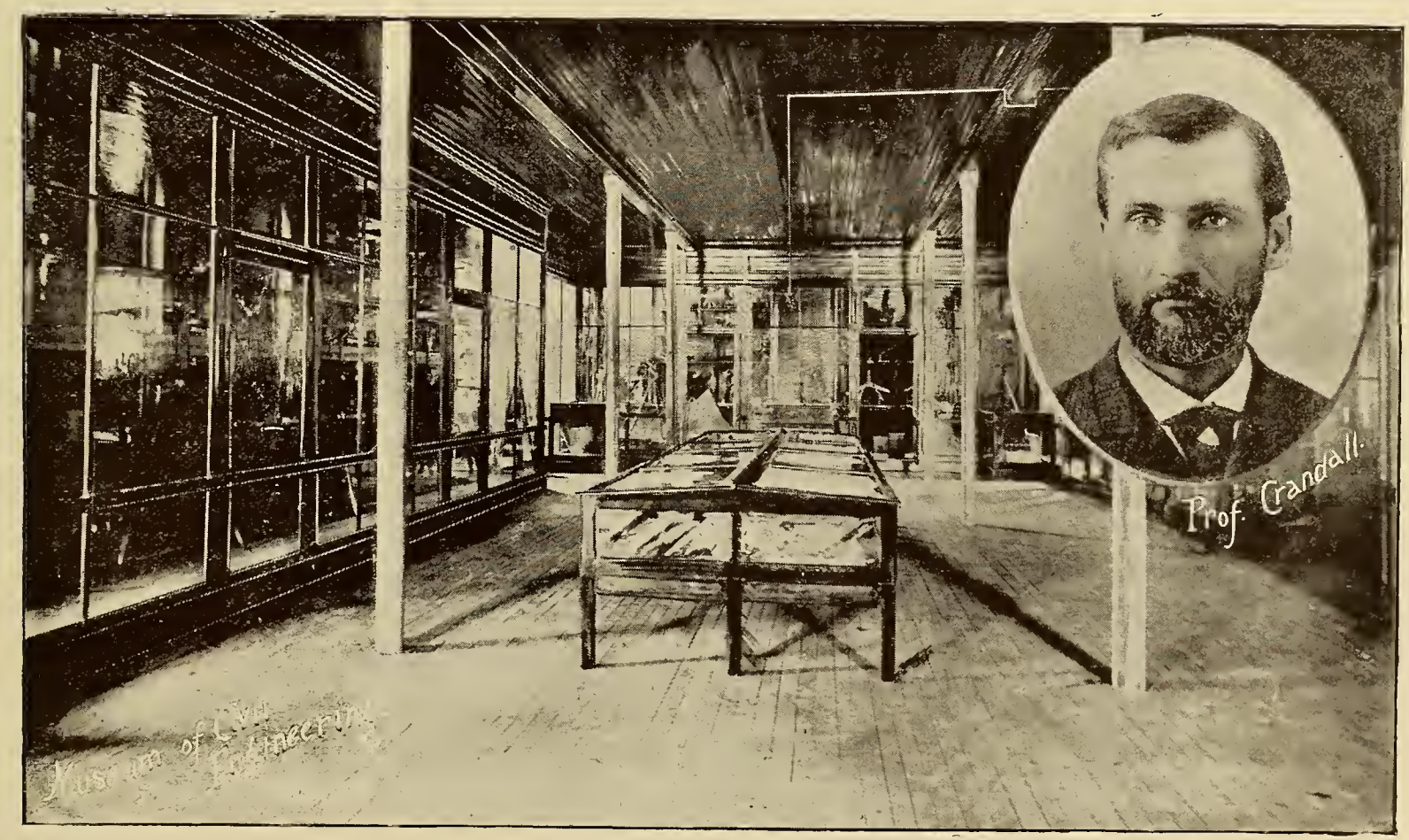
The first floor contains the offices of the Director and his colleagues, the special engineering library, the reading room, two draughting rooms, holding jointly, eighty-six desks, the general museum of the college, the museum of field instruments, and the central office of the New York Meteorological Bureau. The other floors contain eight lecture rooms, three draughting rooms, the meteorological observatory, blue-printing room, photographic laboratory, and an abundance of closet, stock, battery, and store rooms. The building is provided with every convenience for comfort, for the efficiency of the teaching done within its walls, and for the safety of its costly appointments. South of the main building are the training observatories, fitted with instruments of precision for astronomical and geodetic practice.

No graduates of this college are known to be out of employment. They find, readily, remunerative engagements ; generally, before graduation, and are promoted rapidly. The faculty consists of the Director, Professor E. A. Fuertes, and eight other Professors and Instructors.


Lincoln Hall.
Prof. Fuertes.

26. The Museums of the College of Civil Engineering.

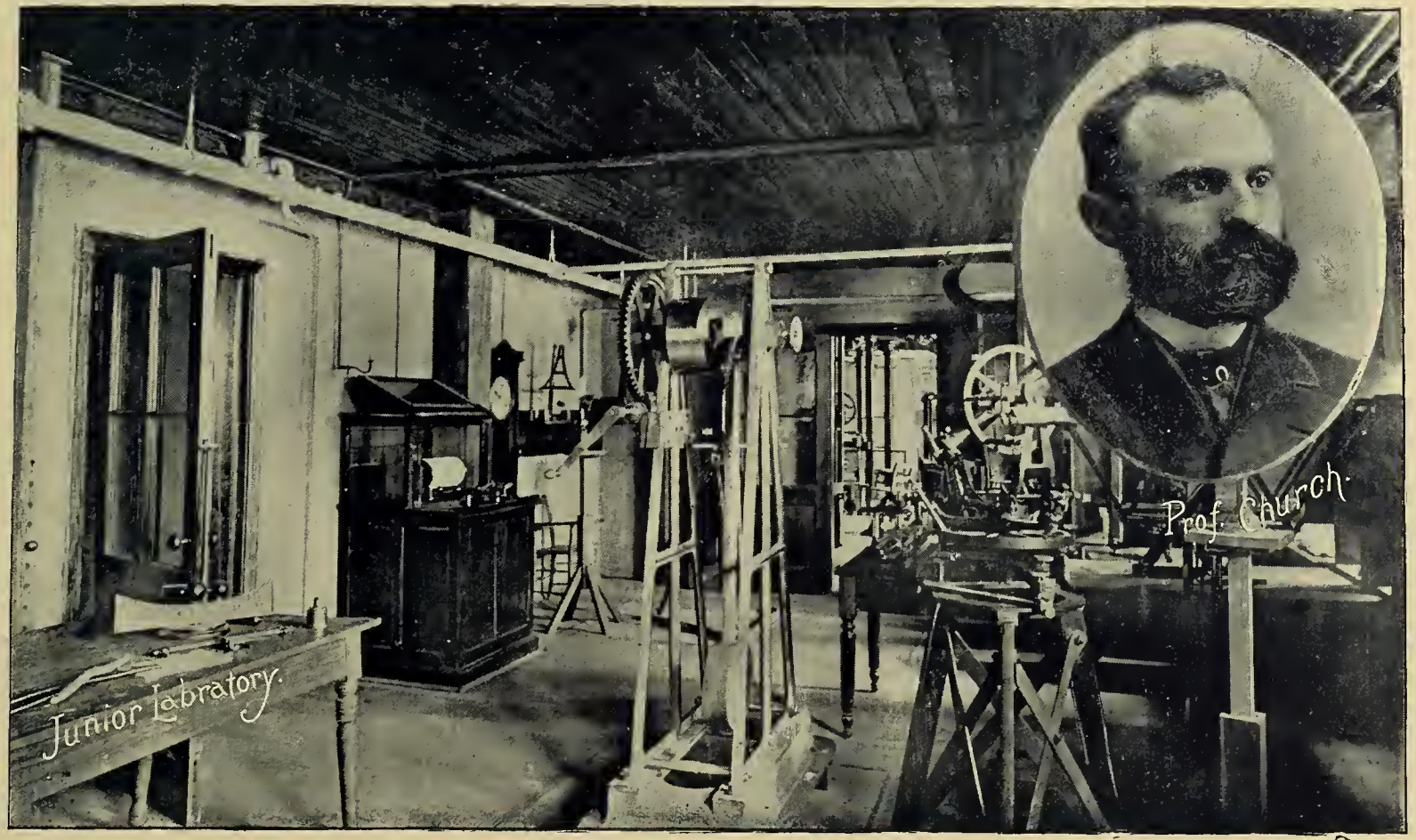
THE GENERAL MUSEUM contains the largest number, and the most expensive sets, of models and appliances as yet collected for similar purposes in this country ; and unsurpassed either in quantity or in usefulness by more than two European institutions. This museum furnishes the illustrative material of the lecture rooms, whilst the laboratories of this college supply the necessary opportunity for personal experimentation. The University owns an unequalled collection of "progress photographs" of engineering works which, in sash-like frames, form the only wall covering of three large rooms and portions of the south hall. The entire collection of designs published by the *École des Ponts et Chaussées*, and several thousand additional engravings and blue-prints, not including library portfolios, are used and on exhibition in all the lecture, draughting, and computing rooms. The museum of field instruments contains, jointly, eighty-three specimens of modern transits, theodolites, altazimuths, omnimeters, tacheometers, plane tables, graphometers, zenith telescopes, sextants, chronometers, chronographs, compasses, levels, etc., besides a numberless variety of special and accessory field instruments, all in actual use for teaching purposes. A skillful mechanician is constantly engaged in the repair and construction of apparatus, with an ample appropriation, and special machinery for these purposes. The Museums are in charge of Professor C. L. Crandall.


Museum of Natural History
Prof. Crandall.

27. The Laboratories of the College of Civil Engineering.

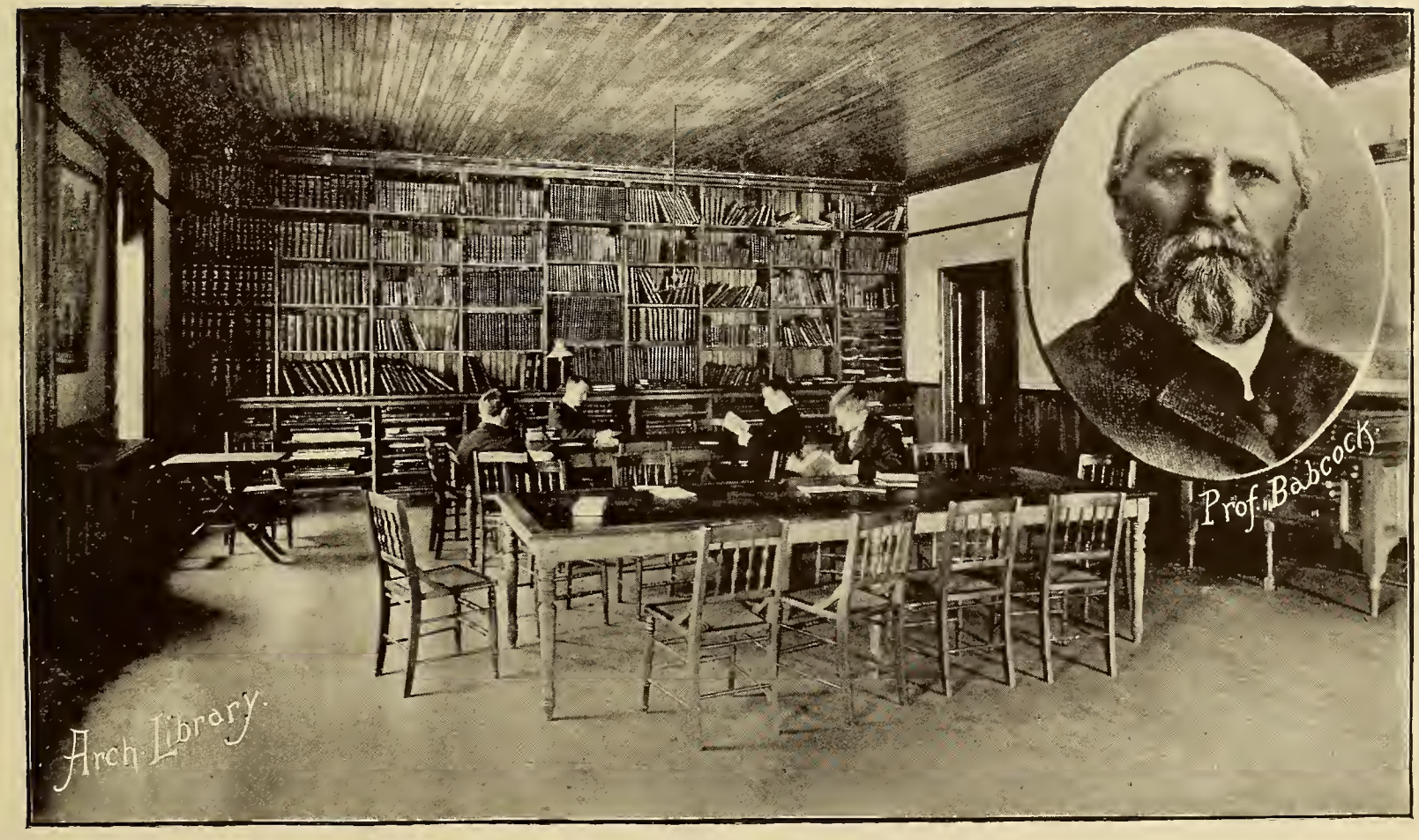
THE ANNEXED VIEW of the Junior Laboratory shows the appliances which verify the mechanical principles developed in the lecture room; this being the most elementary kind of professional instruction given in the laboratories of this college. Adjoining this room are: the Bridge Laboratory, for instruction and investigations under the direction of specialists; the Metric, Magnetic, and Geodetic Laboratories, containing a dividing engine, pendulum, cathetometers, collimators, dip-circle, magnetometers, a specially designed comparator of the highest precision, and the accessory appliances indicated by their purposes in the investigation of "standards" and of the theory and magnitude of errors. In the Cement Laboratory are determined the specific gravity and composition of cements. The sifting, mixing, moulding, time of setting, permeability, and streugth tests, are obtained automatically. Experiments on piling, foundations, and masonry structures are also carried on here; the equipment also embraces an Hydraulic Laboratory, richly equipped for the determination of deliveries, coefficients, etc., and a Sanitary Laboratory for chemical, spectroscopic, bactereological, and biological water analyses, abreast of the modern requirements of its fields.

This college undertakes, gratis, tests, analyses, and investigations, when for public benefit; for private purposes actual cost charges will be made, which can be ascertained beforehand by addressing the Director of this college. The laboratories are in charge of Professor I. P. Church.


Junior Labratory.
Prof. Church.

28. The Department of Architecture.

THE MATERIAL equipment of this department consists of: 1. A library of 1,250 volumes, including many large and costly works, such as "Grecian Antiquities" (Stuart and others), "Canina," "Piranesi," Napoleon's "Egypt," Prisse d'Avennes' "Egyptian Art," Place's "Nineveh and Assyria," Organia's "St. Mark's," "Venice," etc. The historical side of architecture is well represented, and decoration, sanitation, and mechanics fairly so. There are full sets of the leading architectural journals, American and European, and nine of these are on the periodical list. 2. A collection of 1,500 photographs, two thirds of which are on exhibition in McGraw Hall, the remainder being used for instruction in the lecture rooms and study in design. 3. Three hundred models, in wood, stone, and plaster, an entirely unique collection, representing structural forms. 4. Two hundred specimens of the various forms of architectural ornament, sculpture, carving, mosaic, etc., in wood, plaster, terra cotta, stone, glass, and metal. 5. A large number of drawings, made for the special purpose of illustrating the history and theory of the art, and of engravings, colored prints, and blue prints from working drawings of eminent architects. 6. A collection of 150 specimens of marbles, granites, and the like, and many varieties of building stones; bricks, plain, moulded, and ornamented; and tiles of every kind. Professor Charles Babcock is at the head of the department.


Prof. Babcock.
Arch. Library.

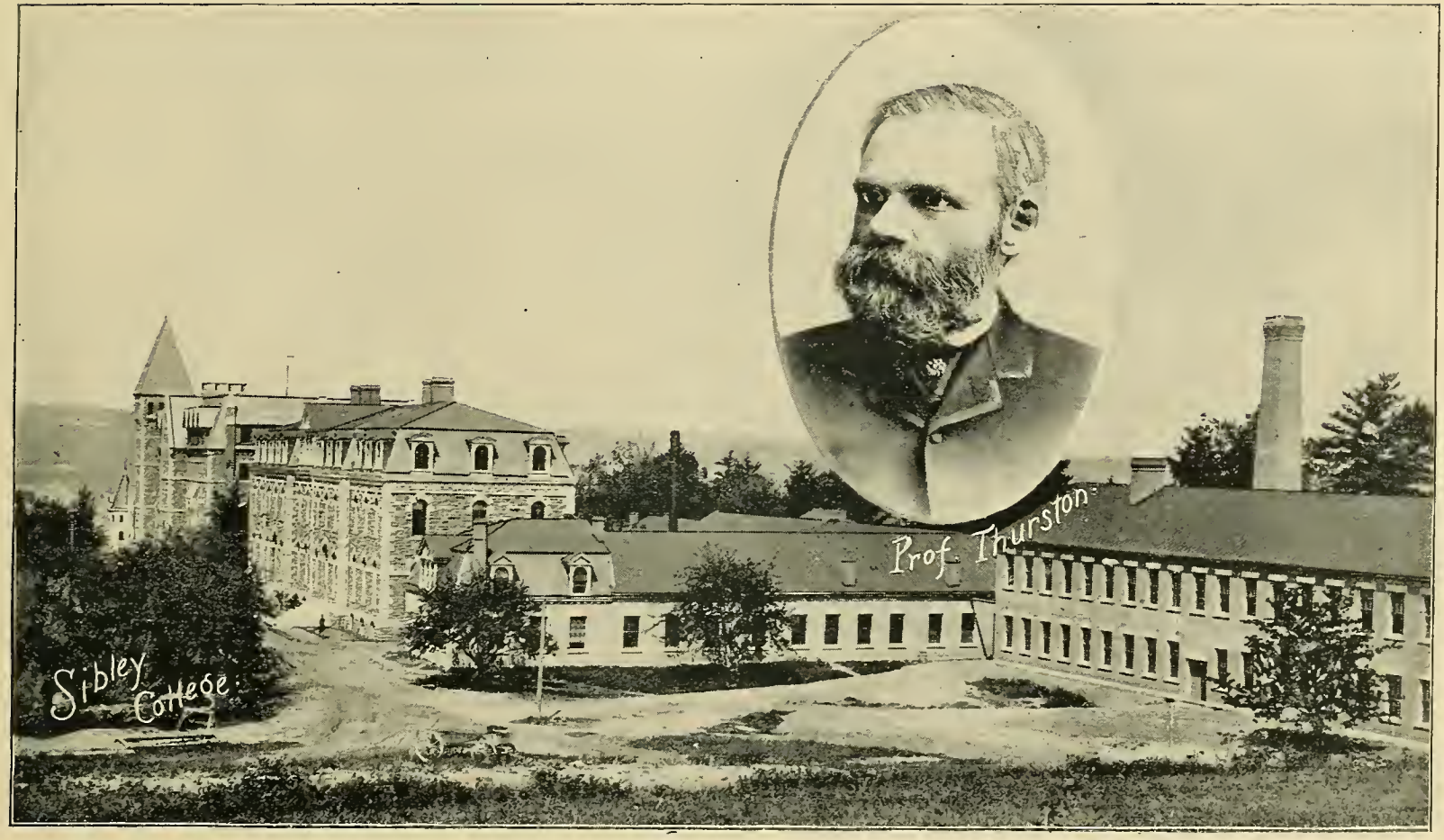
29. Instruction in Architecture.

THE DEPARTMENT of Architecture offers a course of instruction which is designed to cover, as fully as is possible in four years, the whole ground of education for the profession, from the scientific, the historical, the æsthetic, and the practical point of view. Its aim is to give to the student a fair knowledge of things in general as pertaining to his future occupation, and a specially thorough knowledge of the matters that belong exclusively to architects. The course, accordingly, includes a proper amount of mathematics, natural and applied science, and modern languages, such as is required of students in other departments; and, in addition, the various technical subjects in which the architectural student is supposed to take a special interest, drawing, construction, design, history and development of styles, mechanics, decoration, stereotomy, photography, heating, ventilation, acoustics, plumbing, drainage, professional practice, office methods, etc. It is intended that when the student leaves the University he shall be a competent draughtsman, qualified to take at once an advanced position in an architect's office. It is admitted now that the time has come when architecture must be recognized as a learned profession, the leading members of which in the future will be men who have been educated with direct reference to its requirements. Besides the head of the department already named, the instructing force consists of Professor C. F. Osborne and an Instructor.


Arch. Lecture Room.
Prof

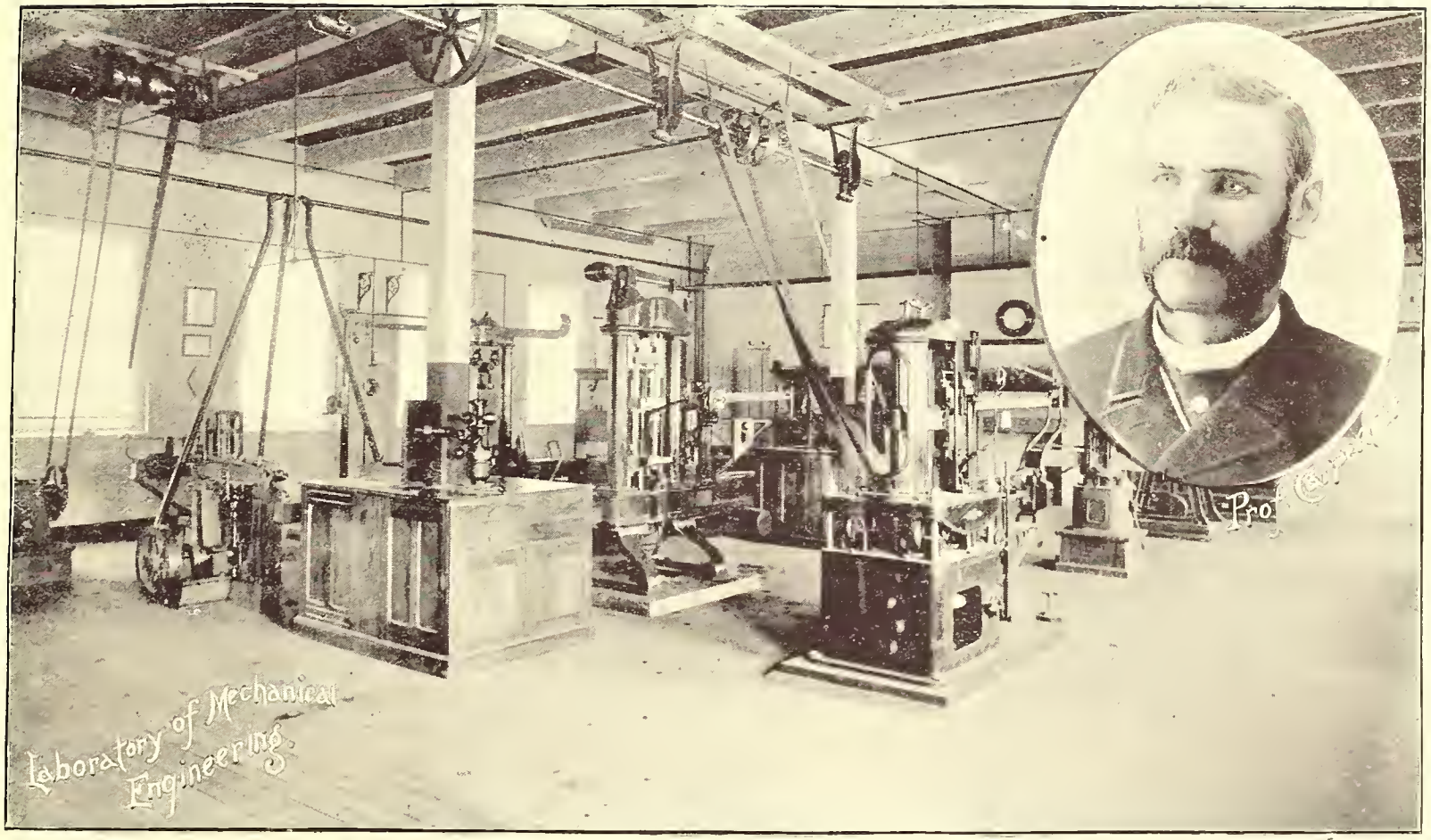
30. Sibley College.

SIBLEY COLLEGE is that section of the University in which is gathered the group of departments constituting the "College of Mechanical Engineering and the Mechanic Arts," which under the provisions of the law of Congress and the Charter of the University, are required to be founded and to be maintained for the purpose of encouraging the useful arts, and to promote the interests of the industrial classes of the State. Its province involves the giving of courses of instruction in the profession of engineering and its branches, so far as they are included under the general term "mechanical engineering," and such as are demanded by those who desire to become proficient in the "mechanic arts." It includes all needed lecture and class rooms, extensive drawing rooms, workshops of equal extent, a mechanical laboratory for the prosecution of engineering investigations and scientific research, and for the instruction of graduate and professional engineers, as well as for the somewhat extensive course of instruction in methods of experimental work provided for undergraduates. Its outfit is commensurate with the magnitude of the college, now the largest of its class, consisting of extensive collections of apparatus of research, models, in great numbers, including the whole "Reuleaux Collection," innumerable drawings of machinery, a large amount of apparatus for special investigation, gathered in the course of the commercial work, a limited amount of which is undertaken when capable of affording profitable instruction, or giving new and valuable information concerning previously obscure points in practice. The corps of instruction consists of the Director, Professor R. H. Thurston, and twelve other Professors and Instructors.


Prof. Thurston.
Sibley College.

31. Laboratory of Mechanical Engineering.

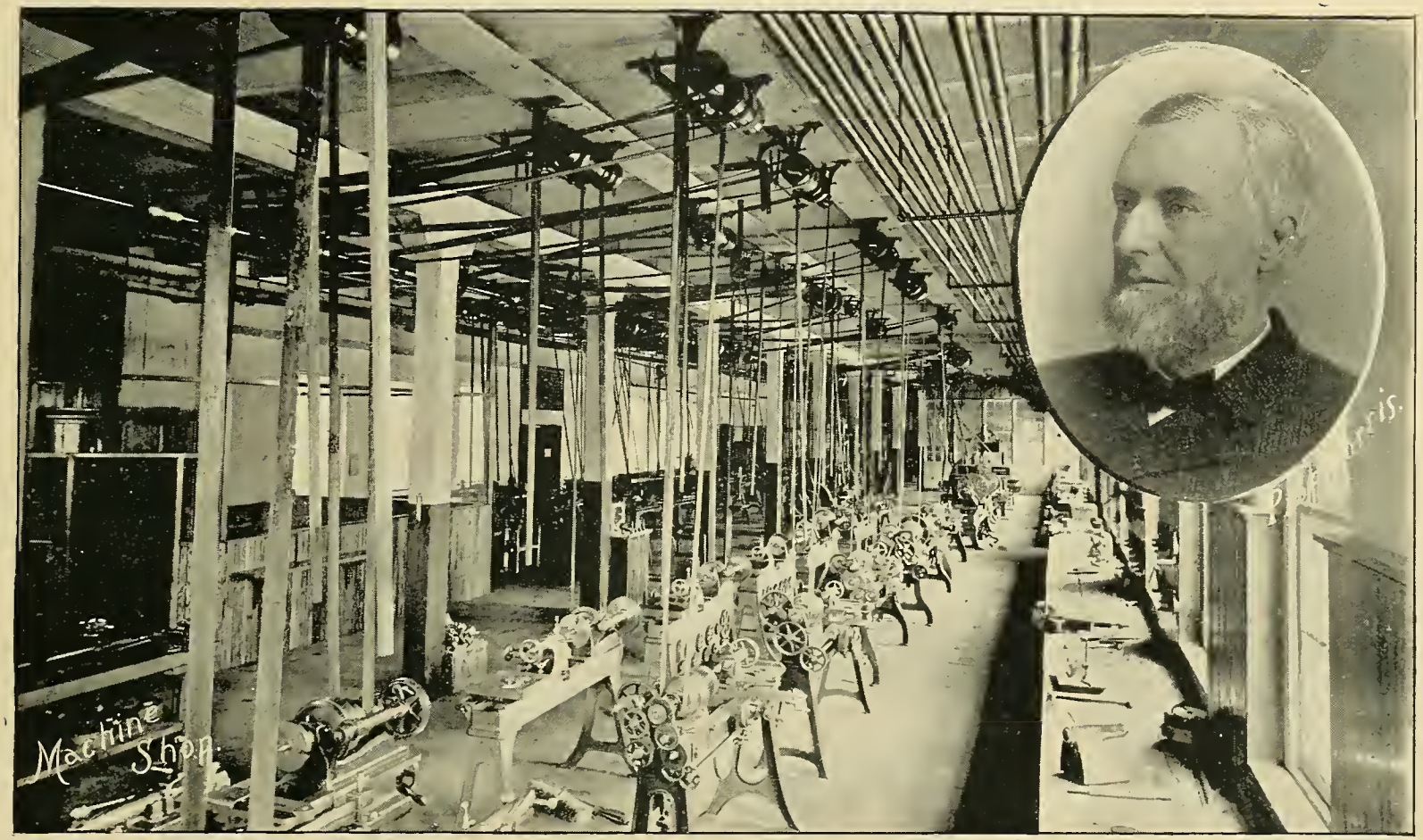
THE LABORATORY of the Department of Experimental Mechanics and Research, intended by the Trustees, from the first, to be made a very prominent part of the establishment, is probably the most extensive and efficient yet organized. Its equipment, arranged for 300 students, and especially as auxiliary to the courses of instruction in graduate work, and for investigation, is also, to some extent, employed in commercial work, where it may be made useful to the University, either in the collection of new facts, the promotion of scientific investigation, or as offering students opportunities to take part in researches of exceptional extent and importance. This equipment includes a series of graded sizes, and various types, of testing machines for determining the properties of the materials of engineering, ranging from a wire and thread testing-machine, to those intended for tests of heavy pieces of metal, ranging in different gradations of a capacity from 10,000 to 300,000 pounds. It includes a number of lubricant-testing machines of various sizes and designs, ranging from the laboratory apparatus to the Railroad Testing Machine, used in the laboratories of the great railways of the country. There are also dynamometers of many forms, a number of calorimeters for determining the quality of boiler-steam, steam-boiler "injectors," air and gas-engines, of the usual standard kinds; and several "experimental engines," among which is a triple expansion engine constructed by Messrs. Allis & Co., built especially to secure the most complete and comprehensive results Professor R. C. Carpenter is in charge of this department.


Laboratory of Mechanical Engineering
Prof

32. The Machine Shops.

THE MACHINE SHOPS constitute that part of the equipment of Sibley College which is especially designed to carry into effect the plans of the Founder of the University, and the Founder of the College, for the promotion of the primary object of organization: the instruction of students from, or about entering, the "industrial classes," in the "mechanic arts," and to supply that knowledge of the trades subsidiary to engineering which must become familiar to every member of the profession aspiring to success and reputation.

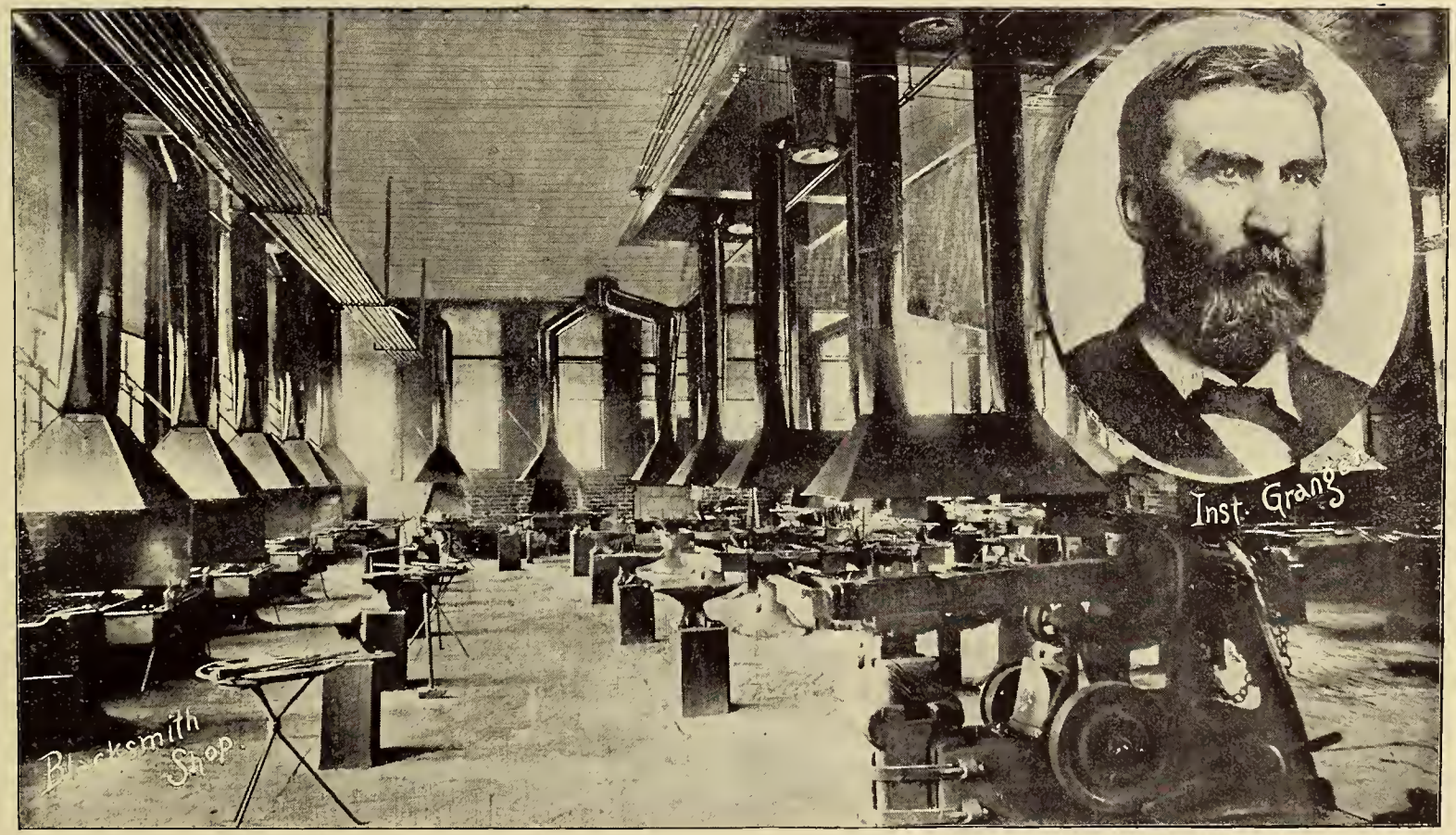
The outfit in the machine shop consists of lathes, planers, milling and shaping machines, etc., sufficient to meet the needs of a class of two hundred; the requirement being, at present, that all candidates for a degree shall spend a specified proportion of their time, for the greater part of two years, in these shops; as well as that all students in "mechanic arts" shall there secure a good knowledge of their proposed vocations. The courses of instruction involve a continual progression, in a carefully planned and nicely graded series of exercises, that shall give a knowledge of all the most important tools and their uses, beginning with the hand tools, the chisel and the file, and concluding with work in the actual construction of finished machines, or elements of machines. These exercises are thus made to lead the pupil from the simplest to the most complex operations, through the whole intermediate range, in such manner that the utmost economy of time, and highest efficiency of instruction are insured. Professor J. L. Morris is the head of the department of Mechanic Arts.


Machine Shop.

33. The Forging Shop.

THE FORGING SHOP furnishes instruction of the most systematic kind to members of the regular sophomore class in mechanical engineering, and to all special students and "mechanic arts" students not applicants for a degree in engineering. It is a large and airy room, containing some two dozen or more forges, with power-hammer, grinding wheel, and accessory apparatus, and the usual hand-tools. A class of one hundred can be handled here, by suitable division into sections; each section commonly working continuously three hours. This shop is unusually well-lighted and ventilated; the heat of its forges being utilized for this purpose, giving a ventilating power of equal efficiency to a steam exhaust-fan of ten horse-power or more.

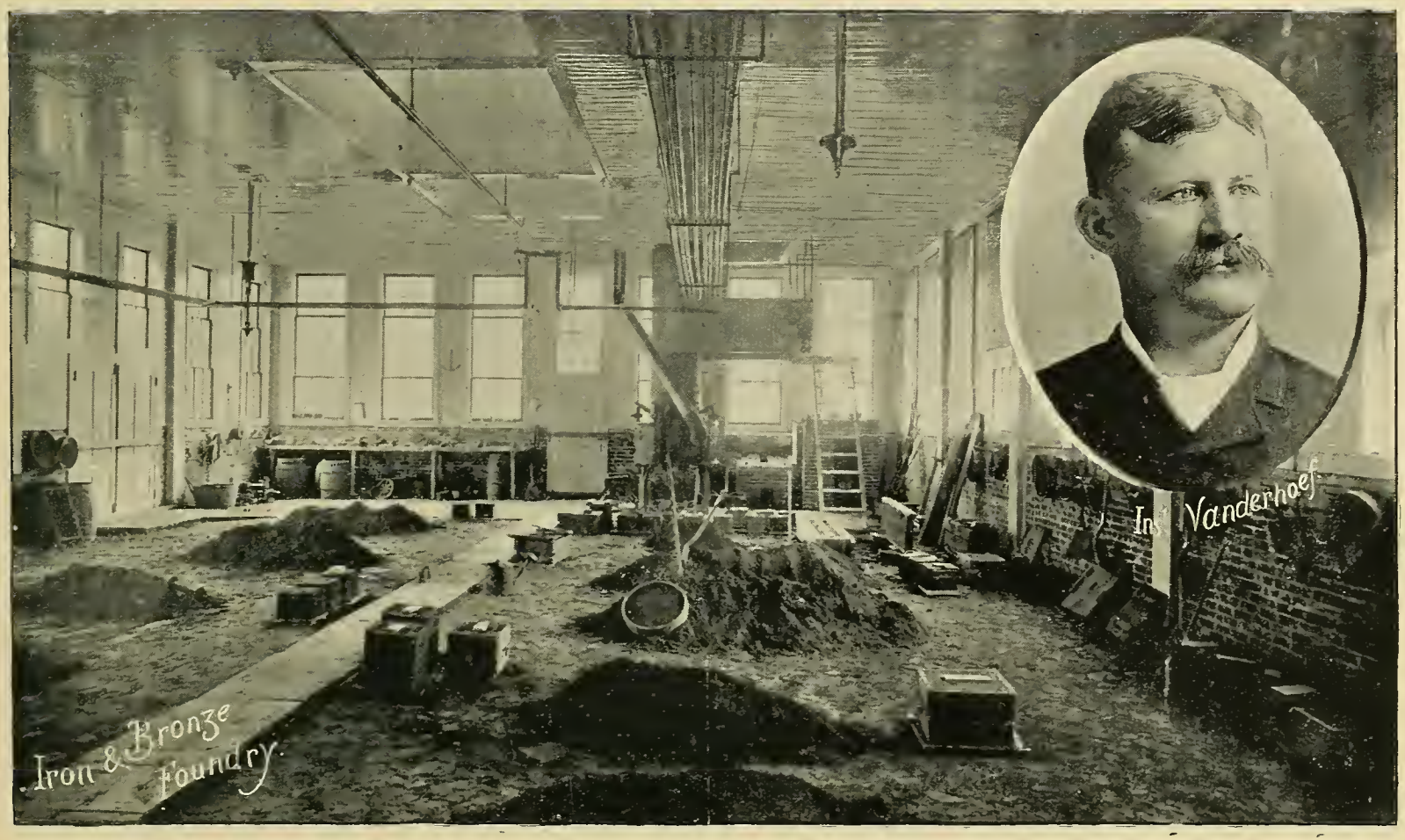
The exercises are graded, as in the other shops, from the simplest to the most difficult, and include instruction in building the fire, and its management; in shaping iron and steel; in welding both metals; and in tool-making and tool-dressing, preparatory to the use of tools in the machine shop. Each student makes, finally, his own machine-shop tools, and carries them with him into that department, when passing into it from the blacksmith shop or foundry. In many cases these tools are admirable pieces of work, and would do credit, as would much of the iron work, to old and experienced artisans. The welding of copper, a most difficult operation, has often been accomplished, after a little instruction, by pupils who had never before seen or handled a blacksmith's hammer. Mr. J. W. Granger is the instructor in forging.


Blacksmith Shop.
Inst. Grang

34. The Foundry.

THE FOUNDRY occupies one-half the building containing the forging shop. It is well lighted, heated, and ventilated; and is one of the pleasantest and most attractive departments of Sibley College. Though the work done here is mainly that familiar in all small foundries, yet the most intricate of castings are often made, and it is difficult to secure patterns from any ordinary establishment which can not be readily and safely moulded by the more advanced students. Like the forging shop, this has proved to be a department of instruction very attractive to students. Some *tours de force* have here been produced that excite the astonishment of even old workmen, among its visitors. A number of ingenious devices have been invented, also, for the production of peculiarly difficult forms.

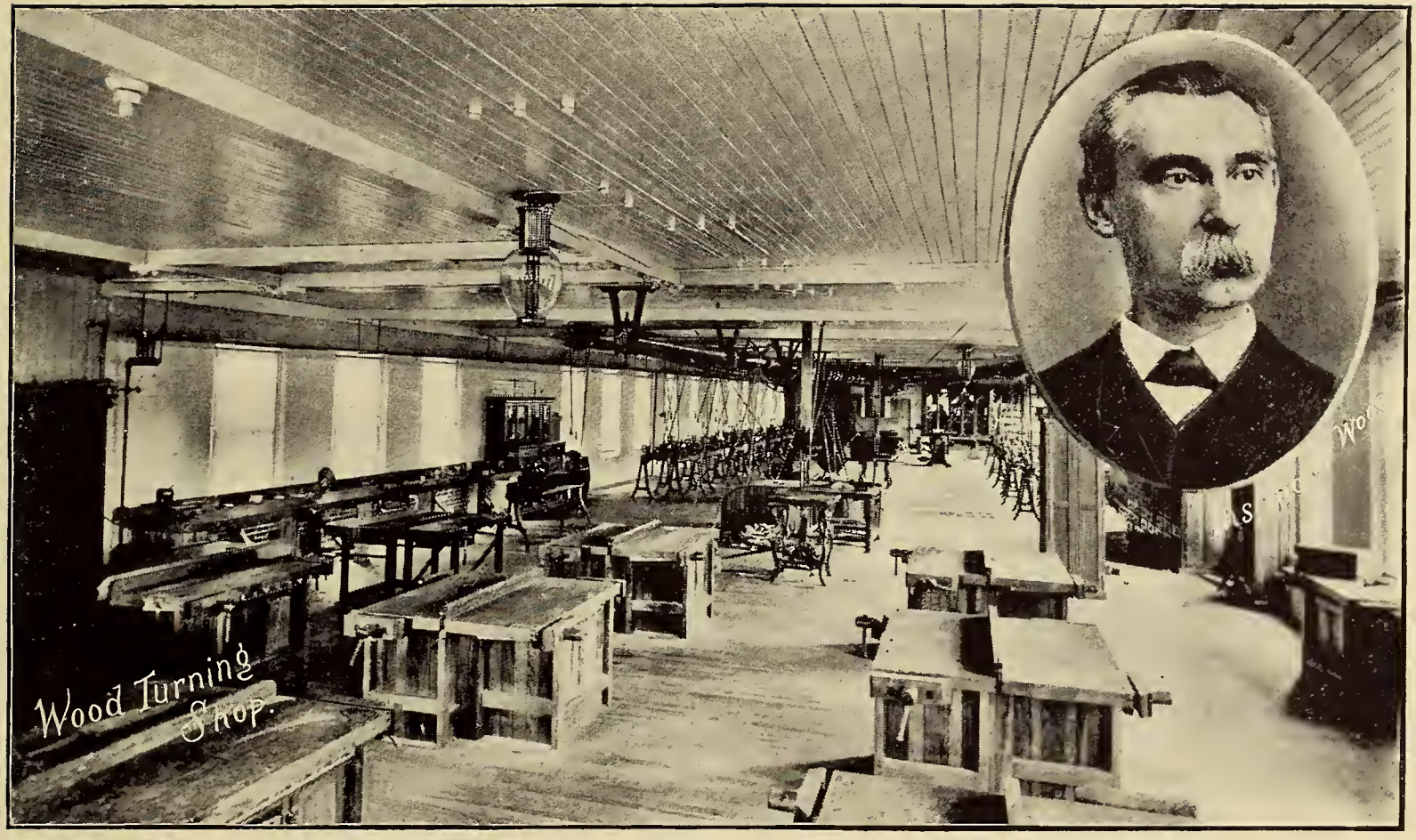
All the castings of the shops, and all the cast-iron work of the University, where not required to be of considerable size and weight, are here made. Among the castings regularly produced may be mentioned the frames and smaller parts of the lathes, forming a portion of the regular work of the shops, all the small pieces for machine shop exercises, and a large amount of incidental and miscellaneous work. The result is not only the affording of opportunities for taking part in such work, but the saving of much otherwise unavoidable expense to the University. Mr. J. E. Vanderhoef is the instructor in moulding.

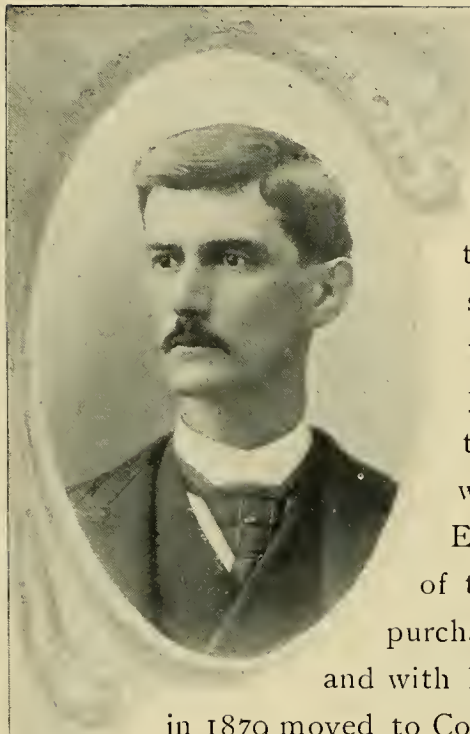

Iron & Bronze Foundry.
Jr. Vanderhoef

35. The Woodworking Shop.

THE WOODWORKING establishment of Sibley College constitutes the first of the series of workshops in which manual training and the regular instruction of young engineers in the trades which are accessory to their profession are given. The student, immediately upon entering the college, begins work in this shop, acquiring, first, a certain ability in the handling of tools and the use of the hand, irrespective of the result of the operations taught; then beginning, as he acquires this skill, with the simplest operations known to the carpenter, the joiner, and the pattern-maker, and going on, step by step, to the most complex and difficult. All the exercises are carefully arranged in this, as in all other departments of the mechanic arts school; and they are all, each year, reëxamined and revised, altered, and improved, as experience indicates to be advisable · thus insuring steady improvement and the best possible course of instruction and practice.

The course begins with bench work, with the chisel, the plane and saw, and embraces the usual operations with those tools, including the construction of various forms and parts of structures, the employment of the turning lathes in the production of forms of revolution. The final work is that of the patternmaker and the joiner, the student learning thus to make the patterns that he is to mould in the foundry later, and making them from drawings made by himself or his college-mates in the drawing-rooms. He thus gains a good knowledge of the use of tools, of the methods of the trades, and the requirements of the designer, as thus modified by the exigencies of actual work. Mr. W. H. Wood is in charge of the Woodworking Shop.


Wood Turning Shop.



The subject of our illustration, Mr. W. T. Adams, the founder and president of the W. T. Adams Machine Co., of Corinth, Miss., was born in Tishomingo County, Mississippi, in the year of 1853. His father, who was a mechanic of moderate means, died about the close of the Civil War, leaving him a lad of twelve years. All of his father's property, with the exception of a home, having been destroyed, and he being the eldest of seven children, felt the responsibility of supporting the family, and set to work with this purpose, finding work on the farm most of the time for three years, being able to attend school only a very small portion of the time. At the age of fifteen he secured a permanent position in a store at Rienzi, Miss., where he worked during the day and studied at night, thus acquiring a good English education and business training. At twenty he was appointed agent of the Southern Express Co., and at twenty-two, having saved a small capital, purchased an interest in a small foundry manufacturing agricultural implements; and with his mechanical turn of mind, and peculiar business tact, succeeding in this, in 1879 moved to Corinth and established the present business; which under his personal management has grown to be one of the most prominent of the kind in the South. He has also aided in promoting many other successful enterprises; and, like many self-made men, has proven a blessing to the country, giving employment to hundreds of hands, and aiding in the development of the resources of the New South.

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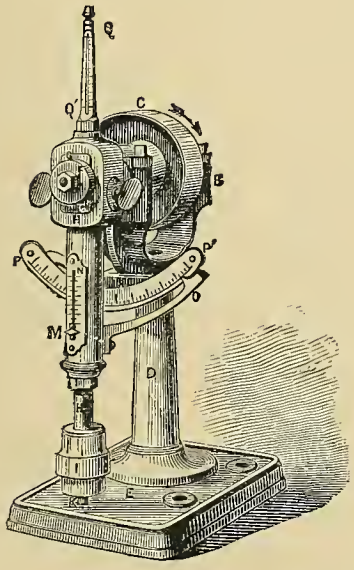

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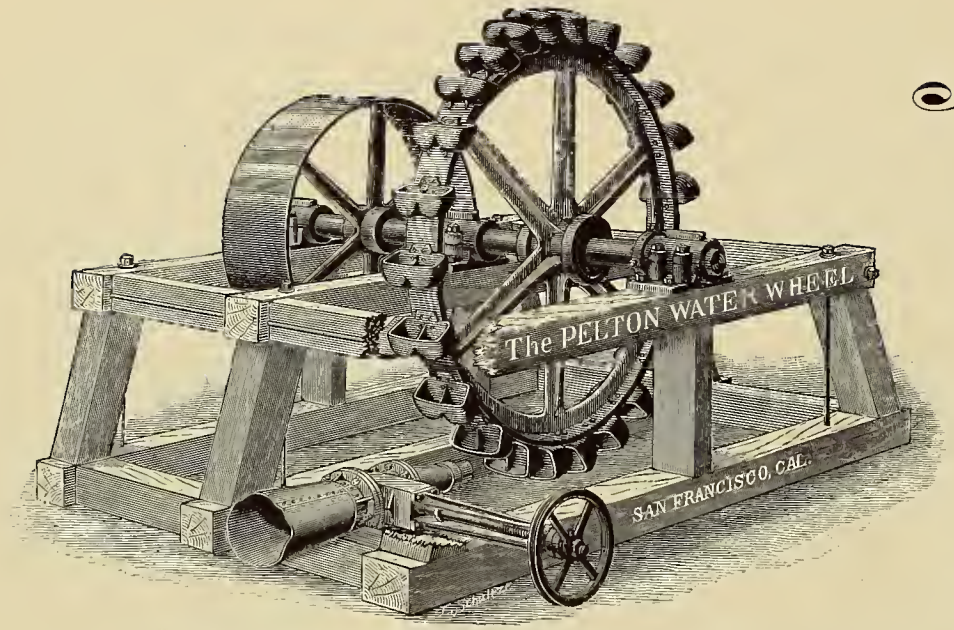

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EXTRACT FROM A PAPER ON TANGENTIAL WATER WHEELS, WITH ILLUSTRATIONS BY ROSS E. BROWNE, MINING AND HYDRAULIC ENGINEER.

SAN FRANCISCO, CAL., November 20, 1890.

THE function of a water wheel, operated by a jet of water escaping from a nozzle, is to convert the energy of the jet, due to its velocity, into useful work. In order to utilize this energy fully, the wheel bucket, after catching the jet, must bring it to rest before discharging it, without inducing turbulence or agitation of the particles. It is plain that this cannot be fully effected, and that unavoidable difficulties necessitate the loss of a portion of the energy. The principal losses occur as follows:

First:—In sharp or angular diversion of the jet in entering, or in its course through the bucket, causing impact, or the conversion of a portion of the energy into heat instead of useful work.

Second:—In the so-called frictional resistance offered to the motion of the water by the wetted surfaces of the buckets, causing also the conversion of a portion of the energy into heat instead of useful work.

Third:—In the velocity of the water, as it leaves the bucket, representing energy which has not been converted into work.

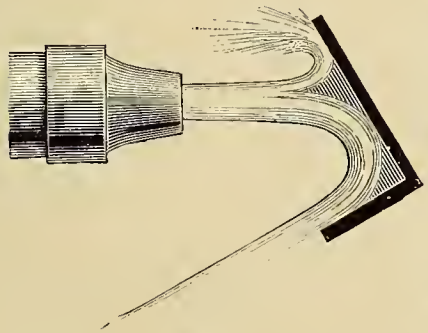


FIG. 1.

Hence, in seeking a high efficiency, there are presented the following considerations:

1st. The bucket surface at the entrance should be approximately parallel to the relative course of the jet, and the bucket should be curved in such a manner as to avoid sharp angular deflection of the stream. If, for example, a jet strikes a surface at an angle and is sharply deflected, as shown in Fig 1, a portion of the water is backed, the smoothness of the stream is disturbed, and there results considerable loss by impact and otherwise. The entrance and deflection in the Pelton bucket are such as to avoid these losses in the main. See Fig. 2.

2d. The number of buckets should be small, and the path of the jet in the bucket short; in other words, the total wetted surface should be small, as the loss by friction will be proportional to this.

A small number of buckets is made possible by applying the jet tangentially to the periphery of the wheel, as provided in the construction of the Pelton.

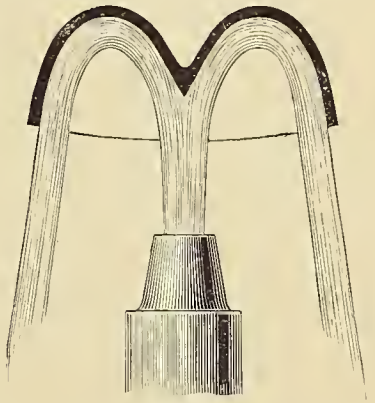


FIG. 2.

3d. The discharge end of the bucket should be as nearly tangential to the wheel-periphery as compatible with the clearance of the bucket which follows; and great differences of velocity in the parts of the escaping water should be avoided. In order to bring the water to rest at the discharge end of the bucket, it is easily shown, mathematically, that the velocity of the bucket should be one half the velocity of the jet.

A bucket, such as shown in Fig. 3, will cause the heaping of more or less dead or turbulent water at the point indicated by dark shading. This dead water is subsequently thrown from the wheel with considerable velocity, and represents a large loss of energy. The introduction of the wedge in the Pelton bucket — see Fig. 2 — is an efficient means of avoiding this loss. A wheel of the form of the Pelton conforms closely in construction to each of these requirements. The entrance and deflection of the jet is smooth and induces very little shock. The discharge from the wheel, when running at proper speed, is almost entirely at the bottom of the wheel, and the amount of water carried over is small, *i. e.*, the loss due to the energy of the discharged water is unusually small. Both feed and discharge are practically tangential. The tangential feed admits of the design with a minimum number of buckets — the bucket is short — in fact, the entire wetted surface is small, and an important advantage is gained over the partial turbines with inner feed. The bucket is open, and the rapid passage of the jet is comparatively free.

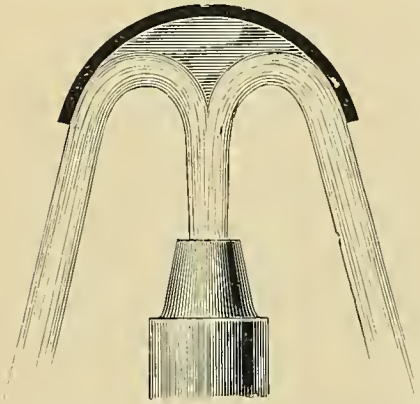


FIG. 3.

In the tests of the Pelton Wheel made by me at the University of California, the diameter of the wheel was 15 inches, the width of the bucket 1.5 inch, and the efficiencies shown under 50 foot head were as follows :

With a 7-16 inch nozzle, 82-6 per cent. With a 3/8 inch nozzle, 82.5 per cent. The efficiency was determined under as low a head as 8 feet, still showing 73 per cent.

It is proper to state that the wheel with which the above tests were made was constructed in the workshop of the University, and did not conform wholly to the company's standard. The size of the bucket was too small to do full justice to the wheel, owing to the difficulty of shaping the curves accurately. It is claimed that tests with larger wheels have given higher efficiencies, and I have no reason for doubting the claim. In connection with the University experiments referred to, comparative tests were also made with a Partial Turbine, and the following conclusion reached : The Pelton wheel, beside giving a higher efficiency, is simpler in construction, has a decided advantage in the setting of the nozzle, and is not so dependent upon the precise size of nozzle used. I do not hesitate to express the following opinions regarding the Pelton wheel operated by circular jets :

1st. It will give a high efficiency under a wide range of heads, say from 20 feet upward.

2d. It will be equally efficient whether operated by very small or very large nozzles, provided the proper ratio is maintained between the diameter of nozzle and size of bucket, etc.

3d. Its general simplicity of construction is a matter of great advantage in its application as a motor. In designing a plant, the size or number of wheels can be more readily adapted to the requirements of speed of shafting and distribution of power, without sacrifice of efficiency or entailment of extravagant cost. It becomes practicable to make more direct applications of the power, frequently enabling the avoidance of counter-shafting, etc.

4th. It meets the requirements of a high-head wheel much more efficiently than do the common forms of turbine. It is evidently far better adapted to high heads than the closed or full-running turbines.

Close turbines are distinctly LOW HEAD wheels, and are not efficient motors under high heads. A high velocity of the enclosed wheel of a full-running turbine causes great agitation and turbulence of the confined water, and it is readily apparent that there occur extravagant losses by impact. The superior efficiency of the Pelton, as a high-head motor, is due to the high efficiency of the circular nozzle, the smooth and rapid deflection of the water in passing through the open bucket, and the small aggregate amount of wetted surface in the buckets.

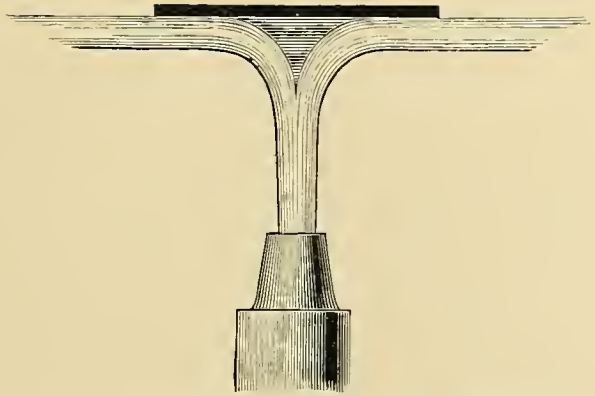
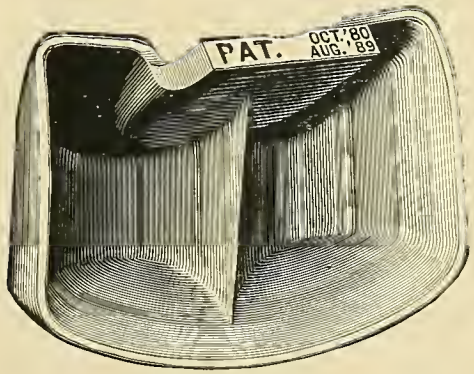


FIG. 3.

CUT SHOWING ACTION OF WATER ON A BUCKET WITH A FLAT SURFACE.



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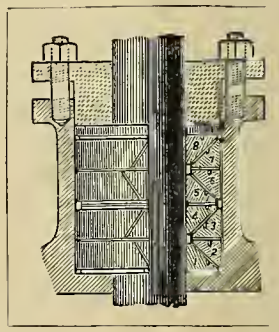

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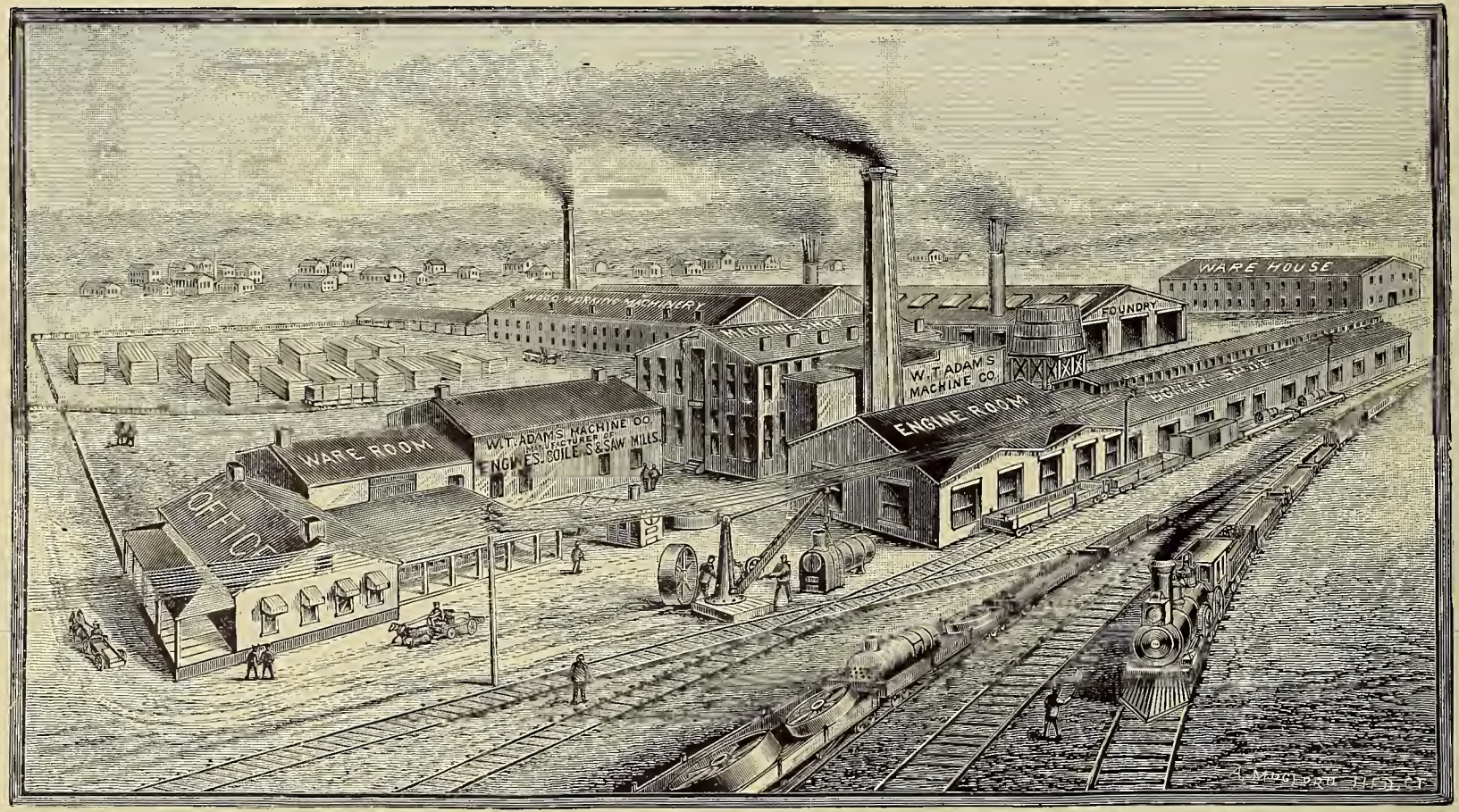

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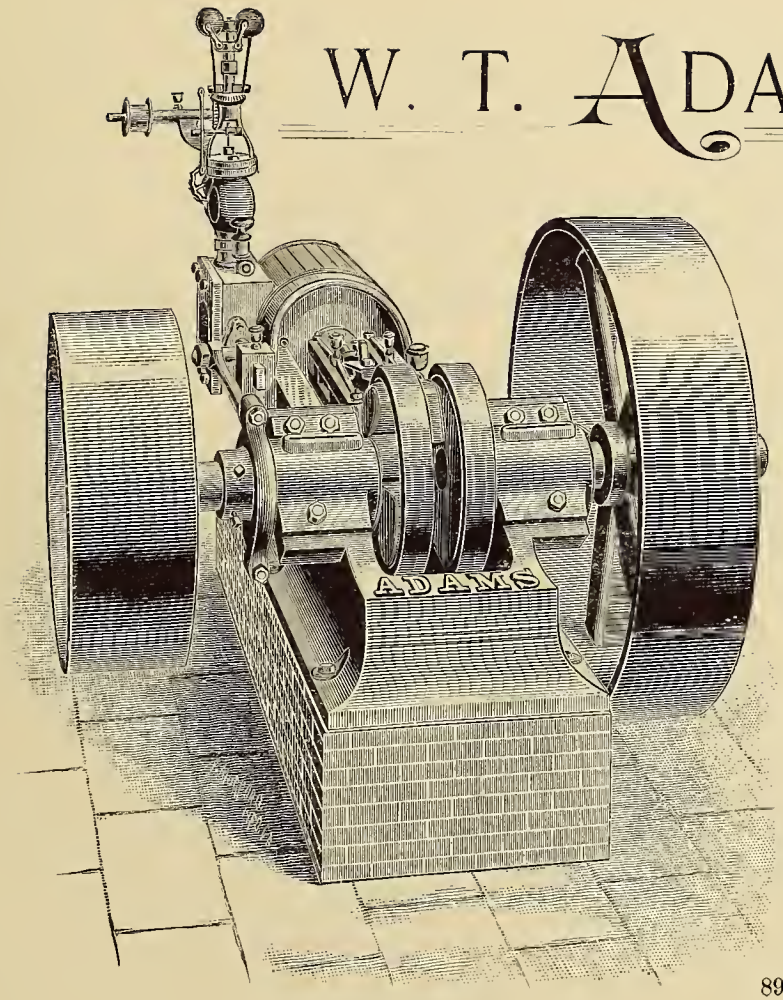

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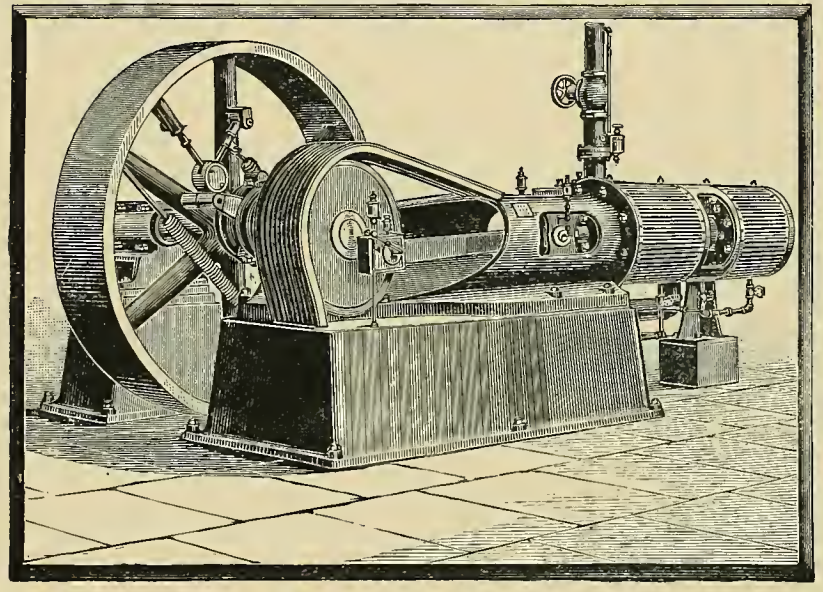

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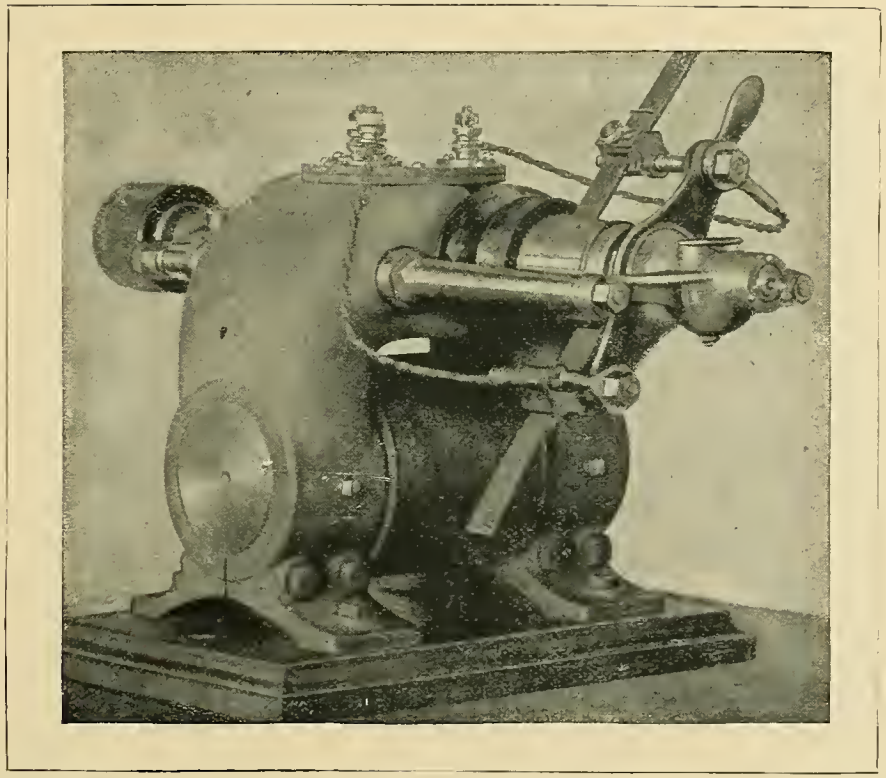

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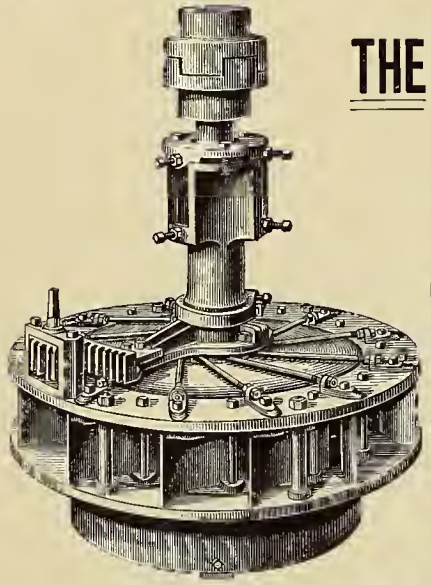

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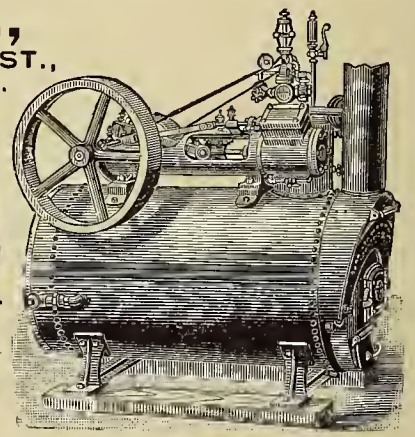

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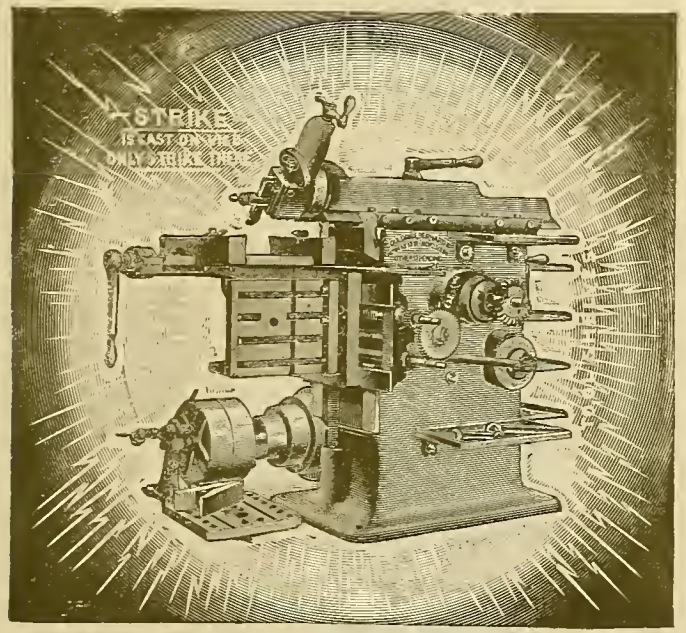

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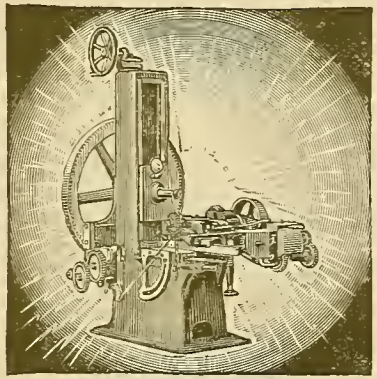

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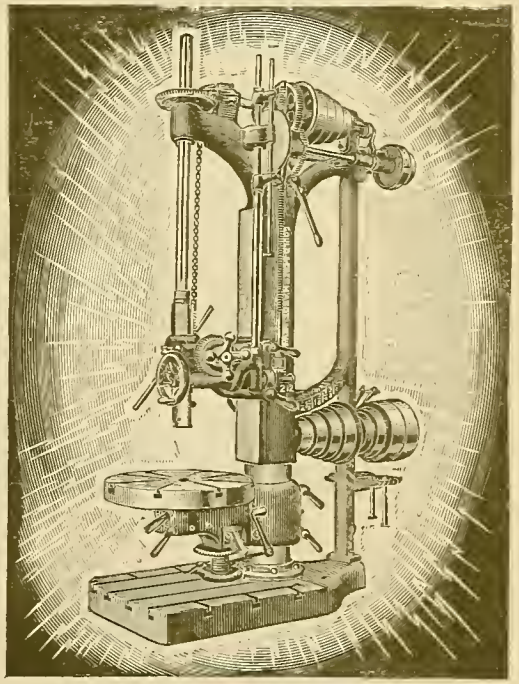

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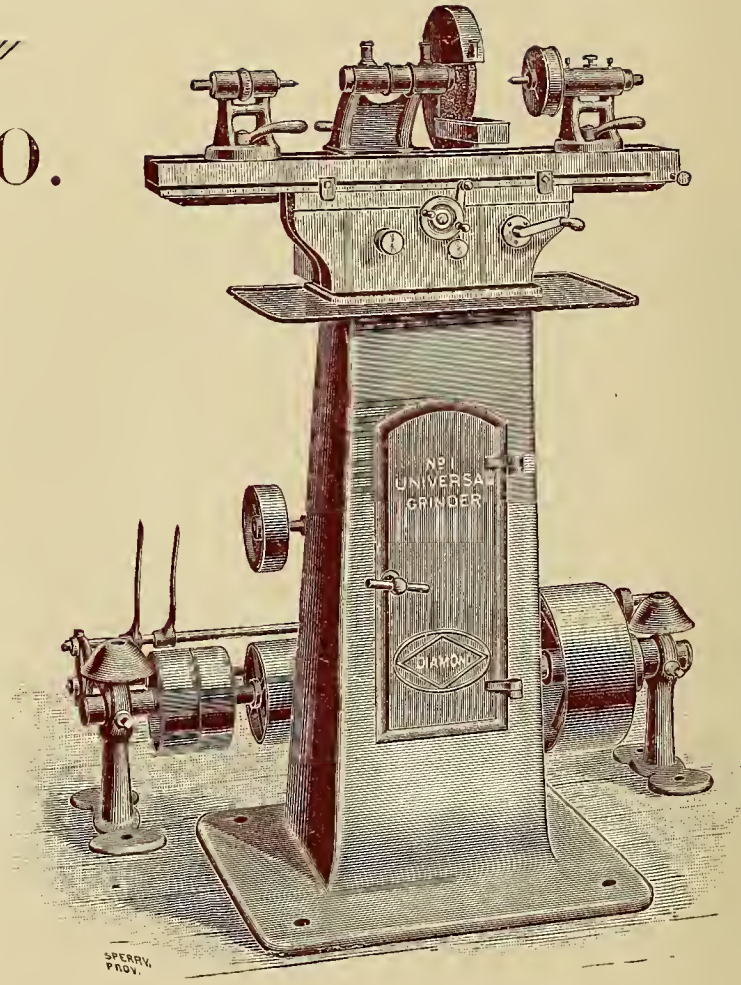

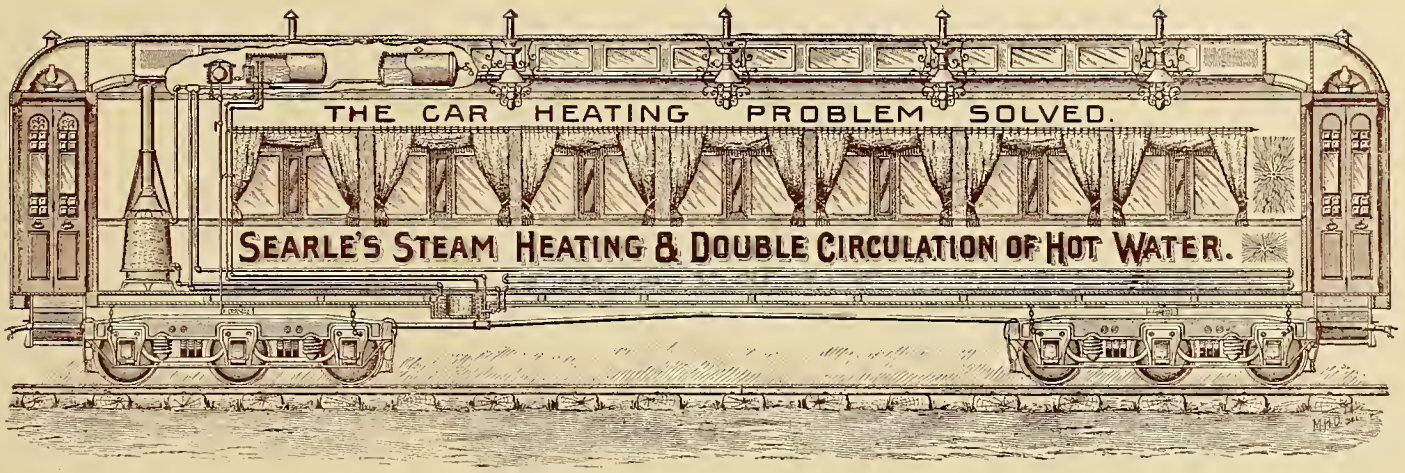

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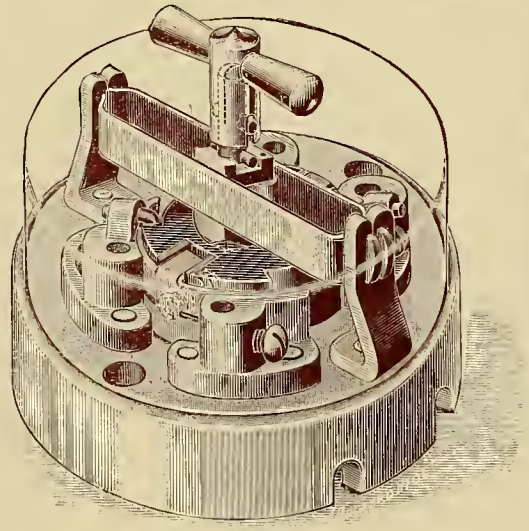

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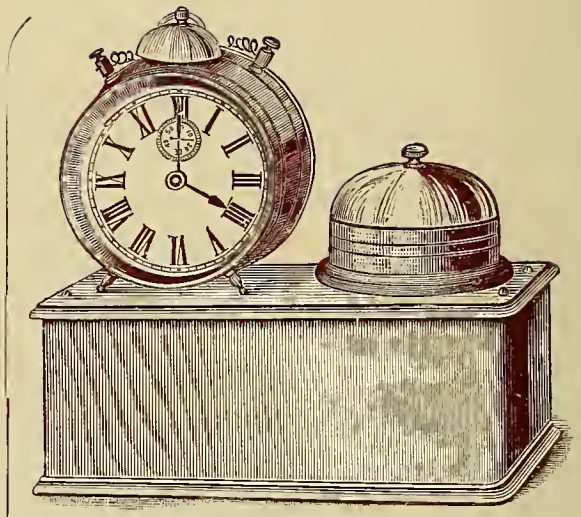

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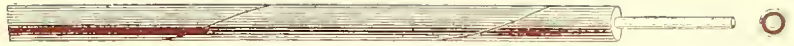

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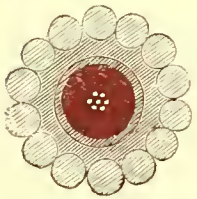

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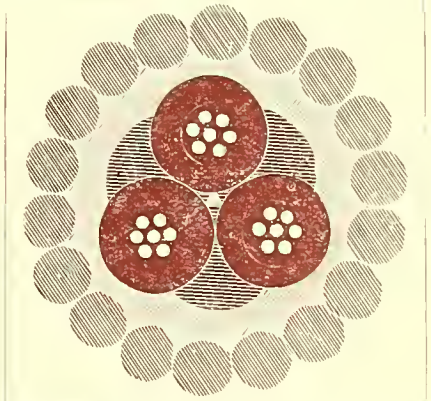

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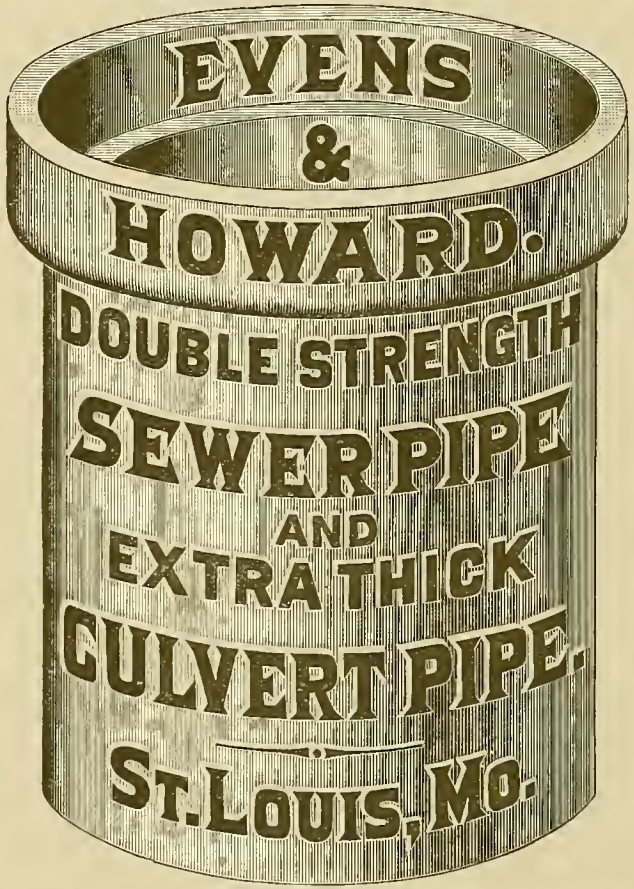

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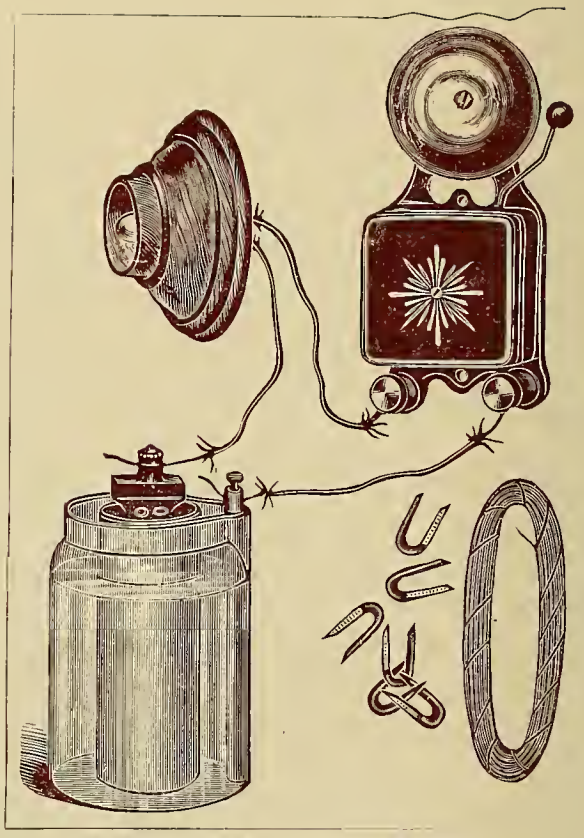

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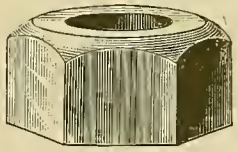

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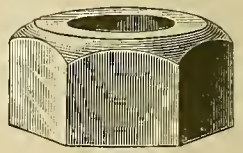

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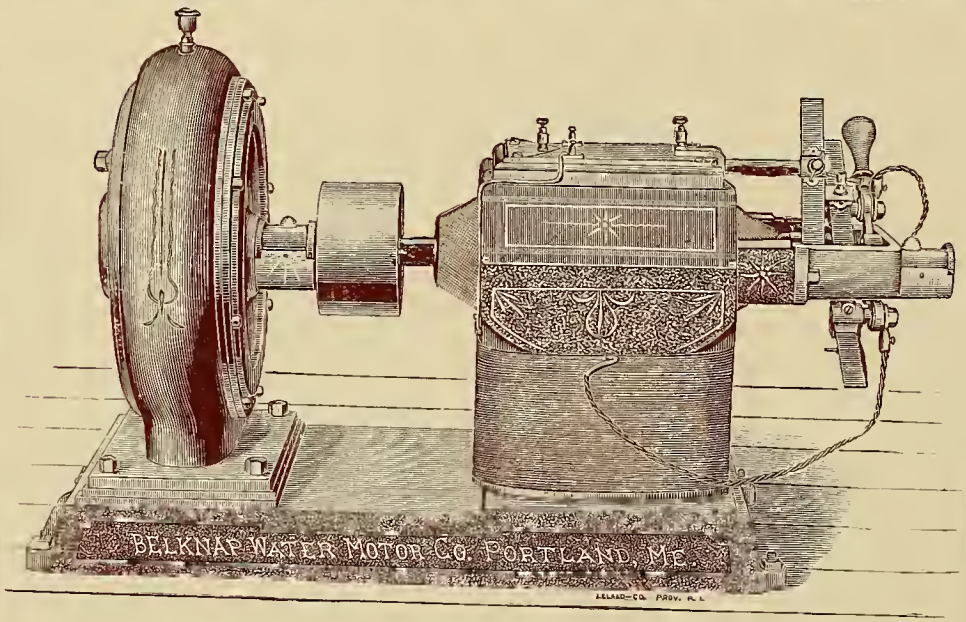

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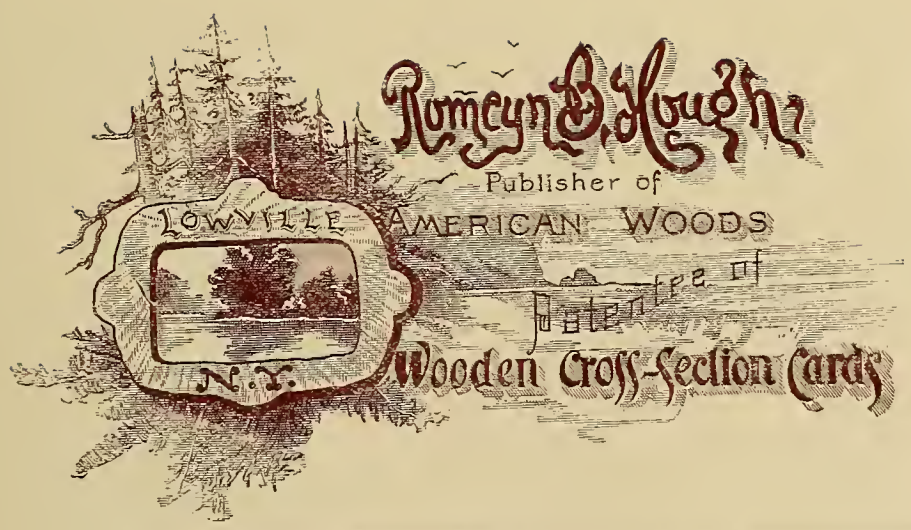

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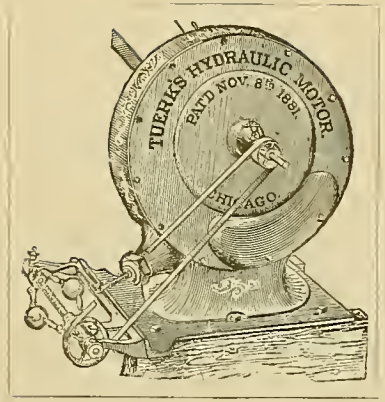

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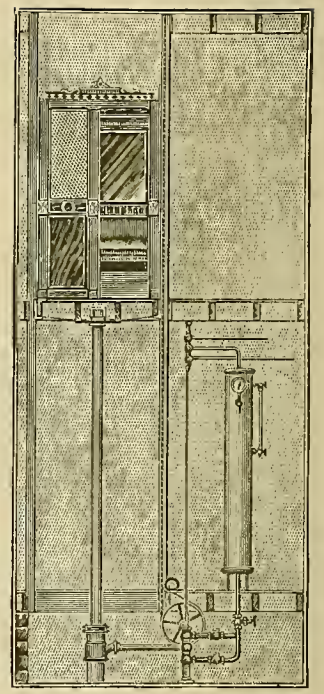

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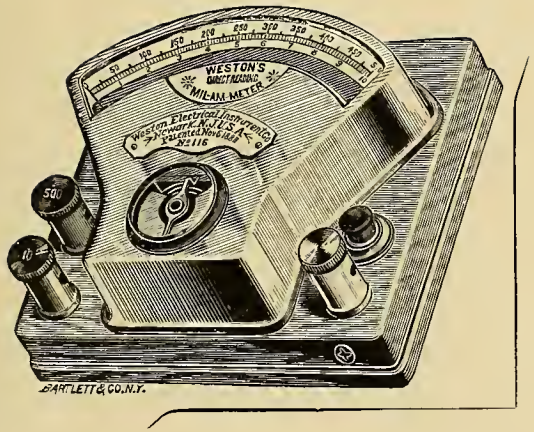

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